INFRASTRUCTURE DESIGN & CONSTRUCTION MANUAL

Chapter 17.5 – Subdivisions, APPENDICES A—G. – RESERVED.

Adopted by reference. The Infrastructure Design & Construction Manual (IDCM) as revised, which can be accessed at https://www.copperascovetx.gov/public_works/.

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WATER DESIGN SECTION

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Subsection I - General.

1. This section presents the criteria, standards and regulations related to the design of water distribution systems for general development service within the City of Copperas Cove water service area.
2. Designs for water system construction and improvements shall conform to the requirements of the Texas Commission on Environmental Quality (TCEQ).
3. Definitions applicable to this section can be found in Section 17.5-2 *Definitions,* City of Copperas Cove Code of Ordinances – Subdivisions.

Subsection II - Waterline Designations.

Waterline Designations are as follows:

1. Transmission water lines are generally lines conveying water from pumping facilities to reservoirs or lines conveying water directly between pumping facilities or directly between reservoirs. Such lines may not be tapped for any purpose without special approval.
2. Distribution water lines are generally lines providing local distribution of water and from which individual user service taps are made. Distribution lines stem from transmission lines or from other local distribution lines.
3. Service water lines are lines providing service from the distribution line directly to the individual's meter.

Subsection III - Facility Location.

1. All water utility facilities not intended for private ownership and maintenance shall be located in one of the following: a dedicated public right-of-way, a dedicated waterline easement, or property deeded to the city.
2. Minimum width of the easement shall be a minimum of fifteen (15) feet, unless the line is located adjacent to a public right-of-way, in which case the minimum easement width shall be ten (10) feet. The City may require greater easement width depending on pipe size, depth, and location. Table 1 shall be used as a guide for waterline easement widths.

Table 1 - Waterline Easement Width Table

		Water Line Size	
		<16"	**≥16"**
Cover Depth	0—5'	15'	25'
	5—10'	15'	**
	10—15'	15'	**
	15—20'	*	**
	>20'	**	**

* 1' of width per each 1' of depth over 15'

** Specifications to be determined by the City Copperas Cove.

3. Prior approval from the city is required before additional uses may be designated for these easements. Water lines should be located so that they can be maintained without disturbing sidewalks, curbs, gutters, structures, or any other utility.
4. The preferred location for new waterlines in new streets is in the street, however, placement behind the curb within the right-of-way is also acceptable. Assignments for major streets should be discussed with the city. Alternative assignments must maintain appropriate separation distances per TCEQ regulations and must be approved by the City.
5. For waterlines within an easement, the alignment shall be generally centered in the easement. All excavation ditches to be a minimum of 2’ off of the easement boundary.

Subsection IV - General Design Requirements.

1. Line Sizes.
   A. The developer's engineer is responsible for sizing all new waterlines within the development and submitting these sizing calculations to the City for acceptance.
   B. Sizing of the lines shall ensure that the required fire flow and potable drinking water requirements of TCEQ are met.
   C. Sizing of off-site waterlines shall conform to the Water Distribution System Master Plan, where applicable. When the City determines that a waterline needs to be larger than required to facilitate future services in the area, the City may require that a waterline be oversized as determined by the Development Agreement.
   D. In other instances, computer modeling is the preferred method for sizing water lines. At a minimum, the design engineer shall submit hand calculations justifying the size of the proposed waterlines.
   E. The following criteria in Table 2, in addition to the requirements of TCEQ, are to be used in sizing new waterlines.

Table 2 – Design Criteria for Line Sizing and Calculations

Hazen Williams Coefficient (PVC)	140
Hazen Williams Coefficient (DI or CSC)	120
Service Unit Equivalent (SUE) [1]	
Single-family residential	1.0
Multi-family residential	0.66

[1] The number of SUEs for commercial uses shall be based on the meter size calculated by the developer's engineer per Section A.5.3.

F. Fire flows shall conform to Insurance Standards Office (ISO) standards and the International Fire Code that the City is using according to Section 4-1. The City of Copperas Cove is currently classified by ISO/PPE as Class 2.

G. The minimum sizes of service lines that shall be per Table 3:

Table 3 – Service Line Size Requirements

Dwelling Units	Minimum Line Size
1	¾"
2	1"
3—6	2"
7—11	4"
12—75	6"

2. Pipe Material. Refer to the City Standard Details and Specifications for pipe material requirements.

3. Fire Hydrants.

   A. For residential zoned property or use, and as the property develops, fire hydrants shall be located at a maximum spacing of six hundred (600) feet as measured along the centerline length of the roadway. No part of a residential structure shall be farther than five hundred (500) feet from the fire hydrant as measured by the route that a fire hose would be laid.

   B. For non-residential zoned property or use, and as the property develops, fire hydrants shall be located at a maximum spacing of three hundred (300) feet as measured along the centerline length of the roadway. No part of a non-residential structure shall be farther than five hundred (500) feet from the fire hydrant as measured by the route that a fire hose is laid.

C. Drain hydrants or permanent blowoff should be located at all low points on transmission lines.

D. Fire hydrants shall be located within the distances from public streets as shown in the City Standard Details and Specifications.

4. Looping.

A. All pipelines, other than those in cul-de-sacs, should be connected to other distribution system pipelines so that all services may receive feed from two directions for system redundancy. Exceptions to this requirement will require approval from the Public Works Director in consultation with the City Engineer.

B. If it is necessary to install water lines between lots to meet flow requirements, no service taps will be installed on such water lines and a valve will be located on each end to allow isolation of such water lines without service interruption.

C. Culs-de-Sac. If a fire hydrant is not required in a cul-de-sac due to distance requirements as outlined in A.4.3, a flushing device shall be installed in accordance with the City Standard Details and Specifications.

D. Trench Safety. Trench safety shall be per the requirements of the City Standard Details and Specifications and the Occupational Safety and Health Administration (OSHA) standards and regulation for worker safety.

Subsection V - Service Connections.

1. Service Lines. House services, single and dual, shall be in accordance with City Standard Details and Specifications. The developer's engineer shall determine service line sizes for multi-family, commercial, or fire lines. The pipe material for these services shall be in accordance with City Standard Details and Specifications.

2. Service Taps.

A. Service Taps shall be per the City Standard Details and Specifications.

B. Direct individual service taps on lines that are 16 inches in diameter or larger are prohibited. These transmission lines are designed to deliver water from a large supply to a large demand area.

i. A parallel distribution main(s) must be constructed to provide for the individual service tap(s).

ii. The parallel main shall be extended across the width of the property frontage in accordance with the City's main extension policy.

iii. These parallel lines shall be connected to the transmission main or other distribution mains at such locations as necessary to facilitate looping of water and to meet TCEQ requirements for water distribution.

3. Meter Sizing. The design engineer shall be responsible for sizing all meters in accordance with AWWA 6 "Water Meters: Selection, Installation, Testing, and Maintenance." The design

engineer shall consider head losses through the selected meter and shall submit his calculations for commercial and multifamily meters to the City for review.

Subsection VI - Valves.

1. Isolation Valve Locations.
    A. Isolation valves should be located on all branches of new mainline tees or crosses, including those cut into an existing main. Fewer valves will be allowed if the design engineer demonstrates that no more than 30 connections will be out of service during a main break.
    B. If an existing main is tapped to make a connection, only one valve at the tap is required.
    C. Additional isolation valves shall be installed on the main at intervals of no greater than 1,000 feet in residential and commercial areas and 2,000 feet on transmission mains.
    D. Isolation valves shall be placed on all fire hydrant leads. Tees for fire hydrant leads only require one valve on the lead. However, the designer is encouraged to coordinate the placement of the additional isolation valves with the location of fire hydrant leads for ease of locating in the future.
2. Air Release Valves. Per the City Standard Details and Specifications.

Subsection VII - Boring and Jacking.

1. The materials and installation of pipe by boring and jacking shall be per the City Standard Details and Specifications.
2. Bores under State highways or large creeks/rivers (generally defined as bores in excess of 100 feet) shall have isolation valves provided on both sides of the bore.

Subsection VIII - Testing.

Per the City Standard Details and Specifications.

Subsection IX - Disinfection.

Per the City Standard Details and Specifications.

WASTEWATER DESIGN SECTION

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Subsection I - General.

This section presents criteria, standards and regulations related to the design of wastewater collection system facilities for general development within the City of Copperas Cove wastewater service area. The material is directed to the competent design professional and is not intended as a detailed design handbook or technical specifications.

Designs for wastewater system construction and improvements shall conform to the requirements of the Texas Commission on Environmental Quality (TCEQ).

Definitions applicable to this section can be found in Section 17.5-2 *Definitions,* City of Copperas Cove Code of Ordinances – Subdivisions.

Subsection II - Wastewater Line Designations.

1. Collection system wastewater line designations are as follows:
    A. Interceptors or trunk mains are gravity sewer mains generally 15-inches and larger.
    B. Collector lines are gravity sewer mains generally 12-inches and smaller.
    C. Service laterals are stubouts extending from a collector main to the right-of-way line or edge of easement to provide customer service. The City is not responsible for the service laterals in right-of-way or easements.
    D. Customer laterals are service lines on private property and are the responsibility of the customer.
    E. Force mains are pipes carrying lift station discharge under pressure.

Subsection III - Wastewater Design Flows.

1. The design flow for new wastewater lines shall be the peak wet weather flow (PWWF), which consists of the peak dry weather flow (PDWF) plus an allowance for wet weather inflow/infiltration (I/I) due to storm events. The peak dry weather flow is the average dry weather flow (ADWF) times a peaking factor (PF). Therefore, PWWF = ADWF * PF + I/I.
2. The average dry weather flow (ADWF) shall be based on the following wastewater unit flow rates:
    A. Single-family residential land use - 75 gal/day/capita; 225 gal/day/dwelling unit.
    B. Multi-family residential land use - 75 gal/day/capita; 112 gal/day/dwelling unit.
    C. Retail land use (wastewater generation generally related to transient clientele) - 225 gal/day per 1000 square feet of building floor space.
    D. Office land use (wastewater generation generally related to stable daytime occupancy) - 65 gal/day per 1000 square feet of building floor space.
    E. Other land use (industrial, educational, medical, etc.) - Wastewater flows will be evaluated on a case-by-case basis where more specific development plans are available.

        * Additional or alternative unit flow rates and supporting data may be submitted to the City for consideration.
3. Peak dry weather flow: PDWF = ADWF * PF

A. The wastewater peaking factor (PF) shall be 4.0 for under 100 acres.

B. For larger areas, the Design Engineer can submit an alternate peaking factor for review by City Staff.

4. Inflow/infiltration (I/I component of PWWF): Calculating extraneous wet weather flows for the purpose of sizing new wastewater lines shall be based on 750 gal/day per acre of new wastewater development area. If the overall service area for new wastewater lines includes older collection system lines, the I/I unit flow rate should be determined in consultation with the City Engineer.

5. Collection system design data should identify potential service area that is beyond the limits of the proposed development that could generate additional flows for proposed sewer improvements. The City will consider the need for oversizing in such cases. Impacts of collection system extensions on existing downstream facilities will be evaluated by the City and will be determined by Development Agreement.

Subsection IV - Determination of Pipe Size and Slope.

1. The minimum pipe size for new wastewater mains shall be 6-inch diameter. Computer modeling is the preferred method for sizing lines. At a minimum, the design engineer shall submit hand calculations justifying the size of the proposed wastewater lines.

2. The design capacity of new sewer mains shall be determined in accordance with TCEQ requirements.

3. The construction plan and profiles sheets shall show the pipe size and slope.

Subsection V - Pipeline Alignment and Location.

1. Sewer mains shall be designed with straight alignment and uniform grade between manholes. Manholes should be located to facilitate access, inspection, and maintenance of the sewer.

2. The standard assignment for sanitary sewer mains is under the pavement in the center of the street. Exceptions to this requirement may be approved by the City Engineer, in consultation with the Public Works Director, provided that the depth from the finished grade to the flowline of the sewer line does not exceed 8 feet.

3. All collection system facilities not intended for private ownership and maintenance shall be located in one of the following: a dedicated public right-of-way, a dedicated easement, or property deeded to the city. In all cases, the separation distance between wastewater and water facilities shall comply with TCEQ requirements.

4. Minimum easement width for wastewater lines shall be fifteen (15) feet. The City may require greater easement width depending on pipe size, depth, and location. The following table can be used as a guide for sewer line easement widths. New sewer lines should not be installed along the side slope of a waterway or drainage system facility. The final alignment may need to take into consideration line location, soil type and line to depth to determine its location and easement size.

Table 1 – Sewer Line Easement Width Table

		Sewer Line Size	
		≤12"	**>12"**
Cover Depth	0—5'	15'	**
	5—10'	15'	**
	10—15'	15'	**
	15—20'	*	**
	>20'	**	**

* 1' of width per each 1' of depth over 15'

** Specifications to be determined by the City Copperas Cove.

5. Selection of sewer main alignments shall be per current TCEQ guidelines and shall minimize the potential for junction manholes with opposing flows from influent pipes. Such manholes shall be designed to avoid solids deposition and minimize turbulence.
6. For sanitary sewer mains within an easement, the alignment shall be generally centered in the easement. All excavation ditches to be a minimum of 2’ off of the easement boundary. All portions of the manholes within an easement are to be placed a minimum of 2’ from the easement boundary to prevent building overhang.

Subsection VI - Pipeline Design.

Pipeline design shall ensure that the pipe classification and installation conditions together provide the required pipe strength to support the anticipated pipe loading in all locations. See City Standard Specifications and Details for design, installation, and construction requirements.

Subsection VII - Manhole Design.

1. Manholes are required at the following locations:
   A. a change in sewer main alignment, slope, pipe size, or pipe material;
   B. sewer main junctions, including the point of force main discharge to a gravity main; and
   C. the ends of sewer lines (no cleanouts will be allowed on public sewer mains).
2. Maximum manhole spacing shall be in accordance with TCEQ requirements.
3. Manholes shall have the following minimum sizing:
   A. 48-inch diameter for pipe connections 15-inch and smaller;
   B. 60-inch diameter for 18 to 24-inch mains;
   C. 72-inch diameter for 30 to 36-inch mains; and
   D. 84-inch diameter for mains larger than 36-inch.
4. Manholes larger than the indicated minimum size or cast-in-place junction structures may be required to accommodate multiple pipe connections. Manholes larger than 60-inch diameter shall have eccentric cone sections.

5. Manholes will be lined at the termination points of force mains and at locations required by the City, in accordance with the City Standard Details and Specifications.

Subsection VIII - Service Lines.

1. The service line from the main to the property line shall be 4-inch minimum size.
2. The minimum slope allowed for service lines is 1.0% (1/8-inch per linear foot). Grade breaks should be made with standard fittings and not exceed 45 degrees. Depth of cover shall be per the Standard Details and Specifications or per the design engineer recommendations.
3. Service connections are not allowed on sewer mains larger than 15-inch diameter, without approval of the Public Works Director in consultation with the City Engineer.
4. Service line connections into manholes are to be on a limited basis, with prior approval from the City Engineer and Public Works. The service line shall be placed to flow a minimum of 1 foot to a maximum of 2 feet above the flowline out invert.

Subsection IX - Force Mains.

1. Design details for proposed force mains shall be included in a technical report for lift station design submitted to the City's Engineer. The technical report should include:
   A. Derivation of design flows based on criteria in Section B.3 herein.
   B. Calculations of system head based on the force main size, length, and profile and for pumping head based on proposed pumps, with operating points indicated for both single and multiple pump operation where applicable.
   C. A drawing of the complete force main pipe profile and the hydraulic grade line profile(s) at the design flow(s).
2. Pumping capacity for the design flows shall be in accordance with TCEQ requirements.

Subsection X - Inverted Siphons.

The use of inverted siphons is discouraged due to high maintenance requirements and will not be allowed on collector lines.

Subsection XI - Construction Plans.

1. The following information should be provided on the construction plans:
   A. Alignment deflection angles at manholes;
   B. Station numbers and pipe invert elevations at manholes, curve starting and ending points, and at even n+00 station numbers; and
   C. Pipe profile for all force mains with appropriate air/vacuum values at necessary locations.

DRAINAGE DESIGN SECTION

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Subsection I - General

1. Purpose.

   This manual represents the application of accepted principles of stormwater drainage engineering and is intended to supplement standard drainage handbooks and other drainage design publications.

2. Definitions.

   Definitions applicable to this section can be found in Section 17.5-2 Definitions, City of Copperas Cove Code of Ordinances – Subdivisions.

3. Layout.

   This manual is laid out in the following fashion, to follow the stormwater from its origin and subsequent flow across the site and through conveyance infrastructure to the stormwater's final destination of natural drainage features:

   A. Stormwater Runoff Determination

   B. Detention Ponds

   C. Street Flow

   D. Underground Stormwater Systems

      i. Inlets

      ii. Piping

      iii. Culverts

   E. Open Channels

   F. Natural Stream and Floodplain Management

   G. Erosion Control

4. Applicability.

   This Drainage Design Section shall govern the planning and designing of drainage infrastructure within the corporate limits of the City of Copperas Cove and within all areas subject to its extraterritorial jurisdiction.

5. Requirements.

   A. If any condition requiring some additional measure or measures of protection is identified during design or construction, it shall be the responsibility of the design engineer to make provisions within the design.

   B. All plans must be signed and sealed by an engineer licensed in the State of Texas.

   C. Computations

      i. Computations to support all drainage designs shall be submitted to the appropriate city departments for review.

ii. Computations shall be in such form as to allow for timely and consistent review and to be made part of the permanent city record.

iii. All submitted computations shall be certified by a professional engineer licensed in the State of Texas.

6. Oversized Facilities.

   If the development is located such that there is considerable drainage from potentially developable upstream areas, the developer may request participation by the city for the cost of over sizing of elements of the overall drainage system. The city shall consider these requests on a case by case basis. Final determination of any cost sharing will be determined in accordance with the Subdivision Ordinance requirements (17.5-95).

7. Grading.

   A. All site developments must provide a site grading and drainage plan that includes drainage computations, detention of runoff (if required) and a detailed site grading plan that does not adversely affect adjacent lots, property or downstream property.

   B. The grading or drainage plan shall include arrows indicating the direction of runoff for each lot.

   C. If typical rear-to-front grading cannot be met due to land slope, topography or existing trees, alternate grading plans may be utilized.

      i. In these instances, it shall be demonstrated to the satisfaction of the City Engineer that grading from front to rear would be more reasonably adaptable to the existing topography.

      ii. All lots that fall into this second category shall be identified on the final plat by a listing table.

   D. Finished floor elevations shall be shown for all lots adjacent to or encroaching upon the FEMA designated 100-year flood plain. Finished floor elevations shall be the minimum distance above the base flood elevation as required in the Flood Damage Prevention Ordinance.

   E. Lot to lot drainage is prohibited except in residential developments where one (1) lot may drain onto one (1) adjacent lot to the rear.

      i. Residential lots may not drain from side to side unless directly adjacent to a city-maintained facility (right-of-way or easement).

      ii. The cumulative stormwater runoff on any single residential lot may not exceed the cumulative stormwater runoff generated from a total of two (2) residential lots.

   F. The applicant for a building permit for a developed lot that is graded from front to rear shall prepare a detailed site grading plan that includes elevations for all corners of the subject lot, all corners of the downstream lot, the finished floor slab elevation, final contours, swales, and any modifications to side yard or rear yard fencing to facilitate removal of runoff from the subject lot.

G. The site grading plan for a subdivision must be sealed, signed and dated by a professional engineer licensed in the State of Texas.

8. Facility Locations

A. All drainage facilities not intended for private ownership and maintenance shall be located in one of the following: a dedicated public right-of-way, a dedicated public utility easement, or property deeded to the city.

B. For drainage facilities within an easement, the alignment shall be generally centered in the easement. All excavation ditches to be a minimum of 2’ off of the easement boundary.

Subsection II - Stormwater Runoff Determination

1. General Requirements.

   A. Stormwater runoff peak flow rates for the 25- and 100-years frequency storms shall not cause increased adverse inundation of any building or roadway surface.

   B. Numerous methods of rainfall runoff computations are available on which the design of storm drainage systems may be based. The method chosen is dependent upon the engineer's technical familiarity and the size of the area to be analyzed. Within the method chosen the design engineer will be responsible for making assumptions as to the development characteristics of the study area.

2. Effects of Urbanization

   It has long been recognized that urban development has a pronounced effect on the rate of runoff from a given rainfall. The hydraulic efficiency of a drainage area is generally improved by urbanization which effectively reduces the storage capacity of a watershed. The result of the improved hydraulic efficiency is illustrated graphically in Figure 1 which is a plot of the runoff rate versus time for the same storm with two different stages of watershed development.

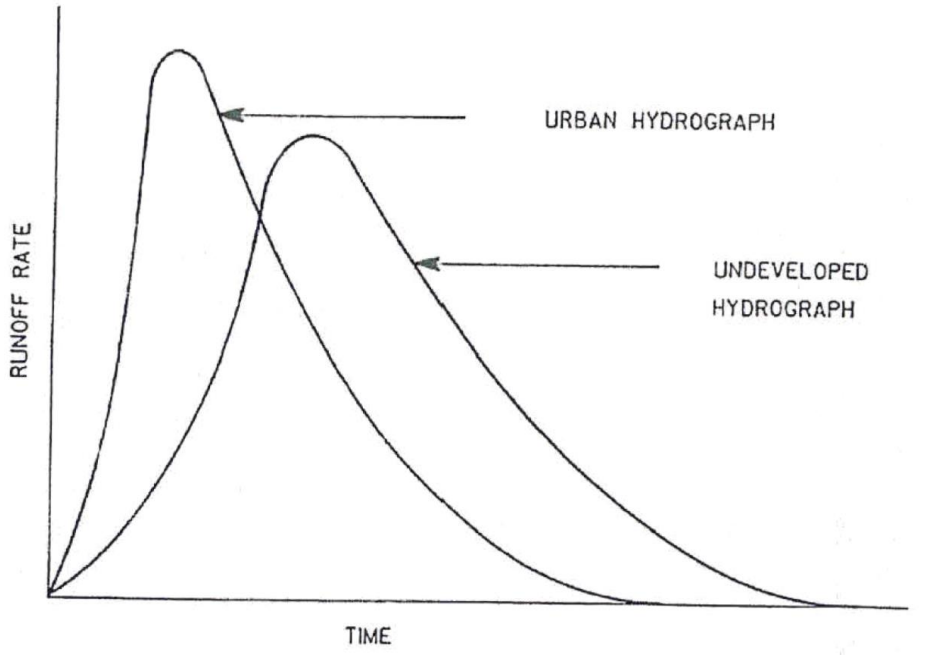


Figure 1 - Typical Effects of Development on Runoff Rates Versus Time

3. Method of Analysis – General Requirements.

   A. The rational method and the variable rainfall intensity method are accepted as adequate for drainage areas totaling two hundred (200) acres or less.

   B. For larger drainage systems, the Natural Resource Conservation Service (formerly the Soil Conservation Service) hydrologic methods should be used.

C. The method of analysis must remain consistent when drainage areas are combined and the method which applies to the largest combined drainage area should be used.

D. The design engineer can use alternate methods, as long as those methods are in keeping with industry standard practice and the chosen method(s) is (are) suitable for the application. The alternate methods, associated assumptions, and suitability for the application must be clearly stated in the design documents.

E. Design Options for Existing Detention Facilities.

i. When analyzing an area for channel and storm drain design purposes, the full existing watershed without detention ponds shall be assumed (except as noted in paragraph ii. below). The selection of design runoff coefficients and/or percent impervious cover factors are explained in subsequent sections.

ii. In the event the engineer desires to incorporate the flow reduction benefits of existing upstream detention ponds, the following field investigations and hydrologic analysis will be required: (Please note that under no circumstances will the previously approved construction plans of the upstream ponds suffice as an adequate analysis. While the responsibility of the individual site or subdivision plans rests with the engineer of record, any subsequent engineering analysis must assure that all the incorporated ponds work collectively.)

a. A field survey of the existing physical characteristics of the outlet structure.

b. Methodology to determine the volume of the pond must meet the requirements of this Design Criteria Manual.

c. Any departure from the original engineer's design must be accounted for.

d. If a dual use for the detention pond exists, (e.g., storage of equipment) then this too should be accounted for.

e. A comprehensive hydrologic analysis which simulates the attenuation of the contributing area ponds. This should not be limited to a linear additive analysis but rather a network of hydrographs which considers incremental timing of discharge and potential coincidence of outlet peaks.

4. Rational Method.

A. The rational method is based on the direct relationship between rainfall and runoff, and is expressed by the following equation:

$$\boldsymbol{Q_P = C \times i \times A} \qquad \textbf{Equation 1}$$

Where:

Q_P = peak runoff in cubic feet per second (cfs).

Note: Q_P is in units of inches per hour per acre (in/hr/ac). Since this rate of in/hr/ac differs from cfs by less than one (1) percent (1 in/hr/ac = 1.008 cfs), the more common units of cfs are used.

C = coefficient of runoff representing the ratio of peak runoff rate (Q_P) to average rainfall intensity rate (i) for a specified area (A).

i = average intensity of rainfall in inches per hour for a period of time equal to the time of concentration (t_c) for the drainage area to the point under consideration.

A = area in acres contributing runoff to the point of design.

The following basic assumptions are associated with the Rational Method:

i. The storm duration is equal to the time of concentration.

ii. The computed peak rate of runoff to the design point is a function of the average rainfall rate during the time of concentration to that point.

iii. The return period or frequency of the computed peak flow is the same as that for the design storm.

iv. The necessary basin characteristics can be identified, and the runoff coefficient does not vary during a storm.

v. Rainfall intensity is constant during the storm duration and spatially uniform for the area under analysis.

B. Runoff coefficient (C).

i. The proportion of the total rainfall that will reach the drainage system depends on the imperviousness of the surface and the slope and ponding characteristics of the area. The variable within the Rational Method used to approximate this proportion is the runoff coefficient, C.

ii. The runoff coefficient C in the rational formula is also dependent on the character of the soil. The type and condition of the soil determines its ability to absorb precipitation. The rate at which a soil absorbs precipitation generally decreases as the rainfall continues for an extended period of time. The soil infiltration rate is influenced by the presence of soil moisture (antecedent precipitation), the rainfall intensity, the proximity of the ground water table, the degree of soil compaction, the porosity of the subsoil, and ground slopes.

iii. It should be noted that the runoff coefficient C is the least precise variable of the Rational Method. A reasonable coefficient must be chosen to represent the integrated effects of infiltration, detention storage, evaporation, retention, flow routing and interception, all of which affect the time distribution and peak rate of runoff.

iv. Table 1 presents recommended ranges for C values based on general surface types. Table 2 presents recommended ranges for C values based on specific land use types.

Table 1 - Runoff Coefficients (C) by Surface Type

Surface Description	Slope	Range of Values		Adopted Value *
		From	To	
Undeveloped				
Cultivated Land	Flat (0 to 2%)	0.31	0.47	**0.39**
	Average (2 to 7%)	0.35	0.51	**0.43**
	Steep (>7%)	0.39	0.54	**0.47**
Pasture/Unimproved	Flat (0 to 2%)	0.25	0.41	**0.33**
	Average (2 to 7%)	0.33	0.49	**0.41**
	Steep (>7%)	0.37	0.53	**0.45**
Wooded	Flat (0 to 2%)	0.22	0.39	**0.31**
	Average (2 to 7%)	0.31	0.47	**0.39**
	Steep (>7%)	0.35	0.52	**0.44**
Floodplains	Flat (0 to 2%)	0.4	0.6	**0.5**
Developed				
Roof Areas	All	0.92	0.97	**0.95**
Asphaltic Areas	All	0.9	0.95	**0.93**
Concrete	All	0.92	0.97	**0.95**
Compacted Crushed Limestone Base	All	0.8	0.9	**0.85**
Grass Areas (lawns, parks, etc.)				
Poor Condition (<50% vegetative cover)	Flat (0 to 2%)	0.32	0.44	**0.38**
	Average (2 to 7%)	0.37	0.49	**0.43**
	Steep (>7%)	0.4	0.52	**0.46**
Fair Condition (50 to 75% vegetative cover)	Flat (0 to 2%)	0.25	0.37	**0.31**
	Average (2 to 7%)	0.33	0.45	**0.39**
	Steep (>7%)	0.37	0.49	**0.43**
Good Condition (>75% vegetative cover)	Flat (0 to 2%)	0.21	0.32	**0.27**
	Average (2 to 7%)	0.29	0.42	**0.36**
	Steep (>7%)	0.34	0.47	**0.41**

* *The "Adopted Value" represents the standard C-value adopted by the City of Copperas Cove. Use of other runoff coefficient values within the provided range is acceptable with proper justification and approval of City Engineer.*

Source: City of Bryan/City of College Station Unified Stormwater Design Guidelines

Table 2 - Runoff Coefficients (C) by Land Use Type

Land Use Description	Slope	Range of Values		Adopted Value *
		From	To	
Park and Open Space	Flat (0 to 2%)	0.25	0.41	**0.33**
	Average (2 to 7%)	0.33	0.49	**0.41**
	Steep (>7%)	0.53	0.73	**0.63**
Single-Family Residential				
Lot size 5,000 to 7,000 sq. ft.	Flat (0 to 2%)	0.5	0.69	**0.6**
	Average (2 to 7%)	0.54	0.74	**0.64**
	Steep (>7%)	0.56	0.76	**0.66**
Lot size 7,000 to 10,000 sq. ft.	Flat (0 to 2%)	0.44	0.62	**0.53**
	Average (2 to 7%)	0.49	0.68	**0.59**
	Steep (>7%)	0.52	0.71	**0.62**
Lot size 10,000 to 20,000 sq. ft.	Flat (0 to 2%)	0.38	0.56	**0.47**
	Average (2 to 7%)	0.44	0.63	**0.54**
	Steep (>7%)	0.47	0.66	**0.57**
Estate Lots (>20,000 sq. ft.)	Flat (0 to 2%)	0.32	0.48	**0.4**
	Average (2 to 7%)	0.38	0.56	**0.47**
	Steep (>7%)	0.42	0.6	**0.51**
Multiple-Family Residential				
Low Density (3 stories or less)	All	0.65	0.74	**0.7**
Medium Density (6 stories or less)	All	0.68	0.76	**0.72**
High Density (more than 6 stories)	All	0.71	0.8	**0.76**
Commercial				
Limited & General Office Sites	All	0.75	0.84	**0.8**
Shopping Center Sites	All	0.79	0.88	**0.84**
Neighborhood Business Districts	All	0.79	0.88	**0.84**
Office Parks	All	0.8	0.88	**0.84**
Central Business District	All	0.87	0.96	**0.92**
Industrial				
Limited (service station, restaurant)	All	0.79	0.88	**0.84**
General (auto sales, rental storage)	All	0.79	0.88	**0.84**
Heavy (parking lots, warehousing)	All	0.87	0.96	**0.92**

* *The "Adopted Value" represents the standard C-value adopted by the City of Copperas Cove. Use of other runoff coefficient values within the provided range is acceptable with proper justification and approval of City Engineer.*

Source: City of Bryan/City of College Station Unified Stormwater Design Guidelines.

C. Time of concentration.

i. General.

a. The time of concentration is the time associated with the travel of runoff from an outer point which best represents the shape of the contributing areas.

b. Runoff from a drainage area usually reaches a peak at the time when the entire area is contributing, in which case the time of concentration is the time for a drop of water to flow from the most remote point in the watershed to the point of interest.

c. Runoff may reach a peak prior to the time the entire drainage area is contributing. Sound engineering judgment should be used to determine the time of concentration.

d. The time of concentration to any point in a storm drainage system is a combination of the sheet flow (overland), the shallow concentrated flow and the channel flow, which includes storm sewers.

e. The minimum time of concentration for any area shall be ten (10) minutes.

f. The following equations for estimating the time of travel under various conditions are taken from the National Resource Conservation Service's (NRCS) National Engineering Handbook, Part 630, Chapter 15 – Time of Concentration, Section 630.1502 Methods for estimating time of concentration, part (b) Velocity Method. For more in-depth discussion and examples of calculations, consult this document or the latest revision thereof.

ii. Sheet flow. Sheet flow is shallow flow over land surfaces which usually occurs in the headwaters of streams and for only very short distances in urbanized conditions. The following equation has been developed for sheet flows of less than three hundred (300) feet.

$$t_t = \frac{0.42 \times (L \times n)^{0.8}}{(P_2)^{0.5} \times S^{0.4}}$$

Equation 2

Where:

t_t = Time of travel, min

L = sheet flow length, ft

n = Manning's roughness coefficient (see Table 3)

P_2 = 2-year, 24-hour rainfall, in

S = Slope of land surface, ft/ft

Table 3 - Mannings n for Overland Flow and Shallow Concentrated Flow

Surface Description	Manning's n [1]
Smooth/Unvegetated	
Concrete (rough or smoothed finish)	0.015
Asphalt	0.016
Fallow (no residue)	0.05
Residue Cover ≤20%	0.06
Residue Cover >20%	0.17
Grass[2]	
Short-grass prairie	0.15
Dense Grasses [2]	0.24
Range (natural)	0.13
Woods[3]	
Light Underbrush	0.4
Dense Underbrush	0.8

1. *The Manning's n values are a composite of information compiled by Engman (1986).*
2. *Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.*
3. *When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.*

a. Shallow concentrated flow. After a maximum of three hundred (300) feet sheet flow becomes shallow concentrated flow. The time of concentration for shallow concentrated flows can be computed from the following equation:

$$t_t = \frac{L}{60 \times V}$$

Equation 3

Where:

t_t = Time of travel, min

L = Flow length, ft

V = Average flow velocity, ft/s

(1) Note the average flow velocity is calculated using the methods outlined in either the NRCS' Technical Release 55 – Urban Hydrology for Small Watersheds, or the National Engineering Handbook, Part 630, Chapter 15 – Time of Concentration, Section 630.1502 Methods for estimate time of concentration, part (b) Velocity Method.

b. Channel or storm sewer flow.

(1) Partial/Non-full flow

(A) The velocity in an open channel or a storm sewer not flowing full can be determined using Manning's equation (Equation 17).

(B) Channel velocities can also be determined by using backwater profiles.

(C) Usually, average flow velocity is determined assuming a bank-full condition.

(D) The details of using Manning's equation and selecting Manning's n values for channels can be obtained from Subsection V - Underground Stormwater Systems and in 0

(E) Open Channels.

(2) For full flow storm sewer conditions (pressure flow) the following equation should be applied:

$$\boldsymbol{V = \frac{Q}{A}}$$ **Equation 4**

Where:

V = Average velocity, ft/s

Q = Design discharge, cfs

A = Cross sectional area, ft^2

D. Rainfall Intensity.

i. Rainfall intensity (i) is the average rainfall rate in inches per hour and is selected on the basis of design rainfall duration and design frequency of occurrence. The design duration is equal to the time of concentration for the drainage area under consideration.

ii. The selection of the frequency criteria is necessary before applying any hydrologic method.

iii. The Copperas Cove intensity-duration-frequency curves are shown in the following Figure 2:

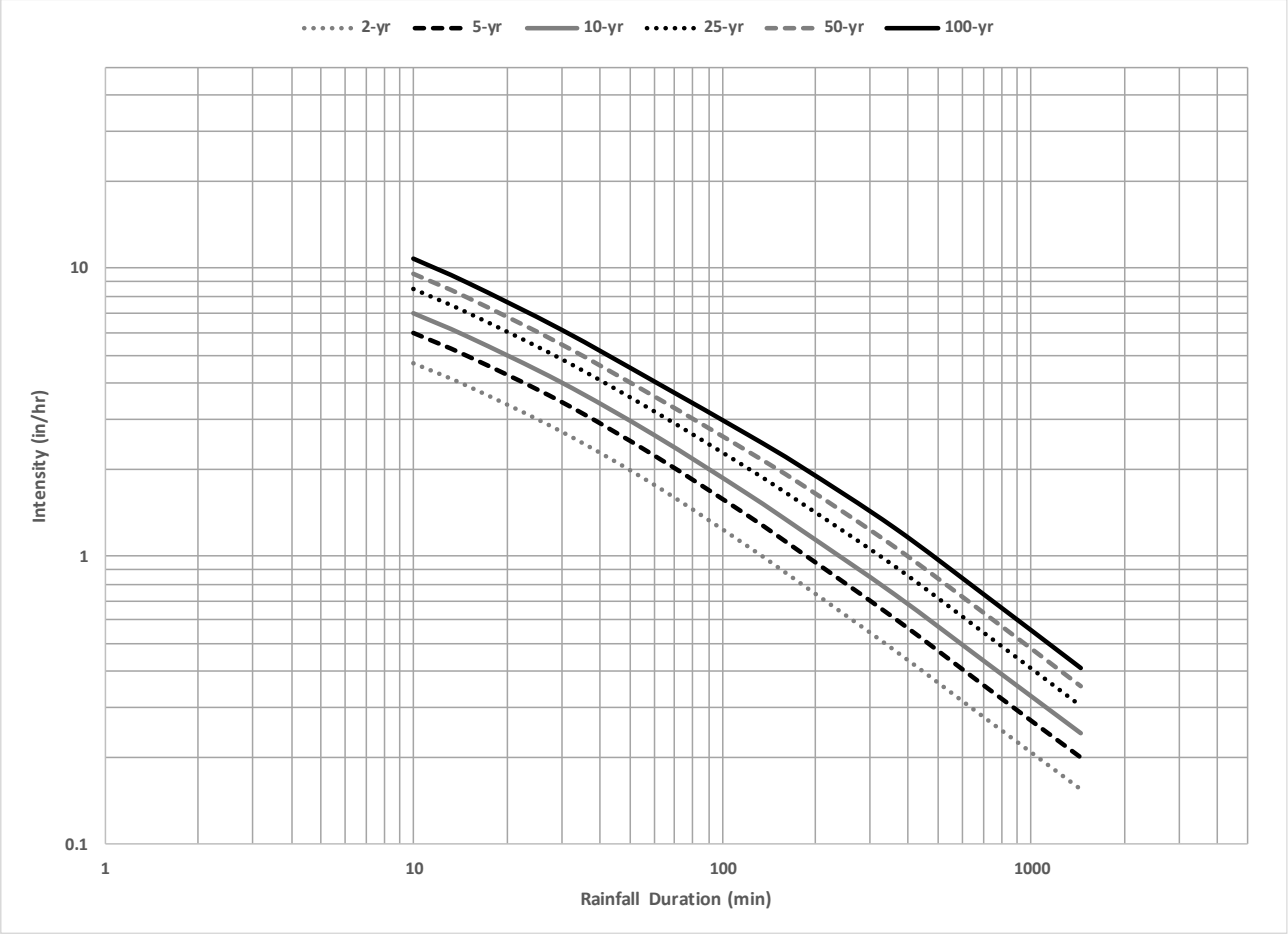


Figure 2 - Intensity-Duration-Frequency Curves for Copperas Cove, TX

iv. Table 4 is the depth-duration-frequency table.

Table 4 - Depth-Duration-Frequency Table for Copperas Cove (depths are in inches)

	Duration								
Recurrence interval (year)	10-min	15-min	30-min	1-hr	2-hr	3-hr	6-hr	12-hr	24-hr
2	0.785	0.98	1.37	1.78	2.18	2.41	2.83	3.25	3.72
5	0.992	1.24	1.72	2.24	2.78	3.1	3.65	4.21	4.81
10	1.17	1.45	2.02	2.64	3.3	3.71	4.41	5.09	5.81
25	1.41	1.75	2.43	3.19	4.06	4.61	5.54	6.4	7.28
50	1.6	1.99	2.74	3.61	4.67	5.35	6.48	7.49	8.5
100	1.8	2.23	3.07	4.06	5.32	6.16	7.53	8.72	9.88

* The values in the table were taken from NOAA Atlas 14 Volume 11 Version 2.

v. Table 5 is the intensity-duration-frequency table. This table was adapted from Atlas 14 Frequency Estimates available on the National Oceanic and Atmospheric Administration's (NOAA) Hydrometeorological Design Studies Center's Precipitation Frequency Data Server.

Table 5 – Intensity-Duration-Frequency Table for Copperas Cove (intensities are in/hr)

	Duration								
Recurrence interval (year)	10-min	15-min	30-min	1-hr	2-hr	3-hr	6-hr	12-hr	24-hr
2	4.71	3.92	2.73	1.78	1.09	0.80	0.47	0.27	0.16
5	5.95	4.94	3.44	2.24	1.39	1.03	0.61	0.35	0.20
10	7.00	5.80	4.03	2.64	1.65	1.23	0.74	0.42	0.24
25	8.47	7.00	4.85	3.19	2.03	1.53	0.93	0.53	0.30
50	9.62	7.94	5.48	3.61	2.33	1.78	1.08	0.62	0.35
100	10.80	8.90	6.14	4.06	2.66	2.05	1.26	0.72	0.41

* The values in the table were taken from NOAA Atlas 14 Volume 11 Version 2.

vi. The use of TxDOT coefficients and equations for the region containing the City of Copperas Cove as outlined in the Hydraulic Design Manual for determining intensity based on duration and frequency is acceptable. The version that is acceptable for use must include the latest published NOAA Atlas Data (Atlas 14 or latest revision).

E. Drainage Area.

i. The size (acres) of the watershed needs to be determined for use in the rational method. The area may be determined through the use of maps, supplemented by field surveys where topographic data has changed or where the contour interval is too great to distinguish the direction of flow. The drainage divide lines are determined by street layout, lot grading, structure configuration and orientation, and many other features that are created by the urbanization process.

ii. The drainage area breakdown needs to be provided in the design documents and submitted to City Staff for review.

5. National Resource Conservation Service methods.

Note: The use of the terms for "Soil Conservation Service (SCS)" methods and "National Resource Conservation Service (NRCS)" methods are considered equal for the purposes of this manual.

A. The former Soil Conservation Service (SCS), now the National Resource Conservation Service (NRCS), created hydrologic methods that have been widely used by engineers and hydrologists for analyses of small urban watersheds. The SCS method utilizes a twenty-four-hour storm duration, which is considered to be acceptable for the Copperas Cove area; however, the design storm most representative of the Copperas Cove area has a three-hour duration. It should be noted that if the SCS storms are applied, the Type III distribution should be used.

B. The SCS methods can be applied to urban drainage areas of any size. A brief explanation of the runoff curve numbers, the tabular and graphical methods and the TR-20 method are introduced in this section. For detailed information, the user is referred to the following NRCS publications (or the latest version thereof). They are:

   i. National Engineering Handbook (NEH), Part 630: "Hydrology".

   ii. TR-20: Computer Program for Project Formulation, Hydrology.

   iii. TR-55: Urban Hydrology for Small Watersheds.

C. Soil conservation service runoff curve numbers.

   i. The NRCS has developed an index, the runoff curve number, to represent the combined hydrologic effect of soil type, land use, agricultural land treatment class, hydrologic condition, and antecedent soil moisture. These watershed factors have the most significant impact in estimating the volume of runoff, and can be assessed from soil surveys, site investigations and land use maps.

   ii. The curve number is an indication of the runoff producing potential of the drainage area for a given antecedent soil moisture condition, and it ranges in value from zero (0) to one hundred (100). The SCS runoff curve numbers are grouped into three (3) antecedent soil moisture conditions. Antecedent moisture condition I is the dry soil condition and antecedent moisture condition III is the wet soil condition. Antecedent moisture condition II is normally considered to be the average condition.

   iii. The SCS has classified more than four thousand (4,000) soils into four (4) hydrologic groups, identified by the letters A, B, C, and D, to represent watershed characteristics.

      a. Group A: (Low runoff potential). Soils with a high infiltration rate even when thoroughly wetted and consisting chiefly of deep, well-drained to excessively drained sands or gravels.

      b. Group B: Soils with a moderate infiltration rate when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse texture.

      c. Group C: Soils with a slow infiltration rate when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water or soil with moderately fine to fine texture.

      d. Group D: (High runoff potential). Soils having a very slow infiltration rate when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high-water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.

   iv. The list of most soils in the United States along with their hydrologic soil classification is given in the TR-55 publication and in NEH Part 630. The minimum infiltration rates for the four (4) soil groups can be found in Appendix A of TR-55.

   v. The curve numbers for the four (4) soil groups under various land uses, land treatment and hydrologic conditions can be found in TR-55 or NEH Part 630. In order to determine

the soil classifications in the Copperas Cove area, the SCS Soil Survey of Coryell County, Texas should be used.

D. Time of concentration.

The procedures for estimating time of concentration for the SCS/NRCS method are described in the NRCS's technical release 55 (TR-55) and in NEH Part 630.

E. Peak flow calculation. The NRCS has presented several methods for computing runoff hydrographs for drainage areas. The tabular, graphical and TR-20 methods are considered acceptable for the Copperas Cove area. The parameters required to calculate the hydrograph are the rainfall distribution, runoff curve numbers, time of concentration and drainage area.

i. Tabular method.

For full information and examples of the tabular method the NRCS publication TR-55 and NEH Part 630 should be consulted.

ii. Graphical method.

For full information regarding the Graphical Method the NRCS publication TR-55 and NEH Part 630 should be consulted.

Subsection III - Detention Ponds

1. General.

   A. Facilities such as detention, retention, extended detention, infiltration, and sedimentation ponds have proven to significantly reduce downstream flooding, reduce sediment and pollutant loads, and provide debris removal which can benefit water quality.

   B. The basic concept of detention for peak rates of runoff is to provide for a temporary storage of stormwater runoff. Runoff is then released at a controlled rate which cannot exceed the capacities of the existing downstream drainage systems, or the predeveloped peak runoff rate of the site, whichever is less.

   C. The solid lined hydrograph shown in Figure 3 represents a storm runoff event without detention, while the dashed line hydrograph depicts the same event with detention. The peak flow of the un-detained hydrograph could exceed the capacity of the downstream conveyance system and thereby cause surcharging and flooding problems. With the introduction of detention, the solid lined hydrograph is spread over a longer time period and its peak is reduced.

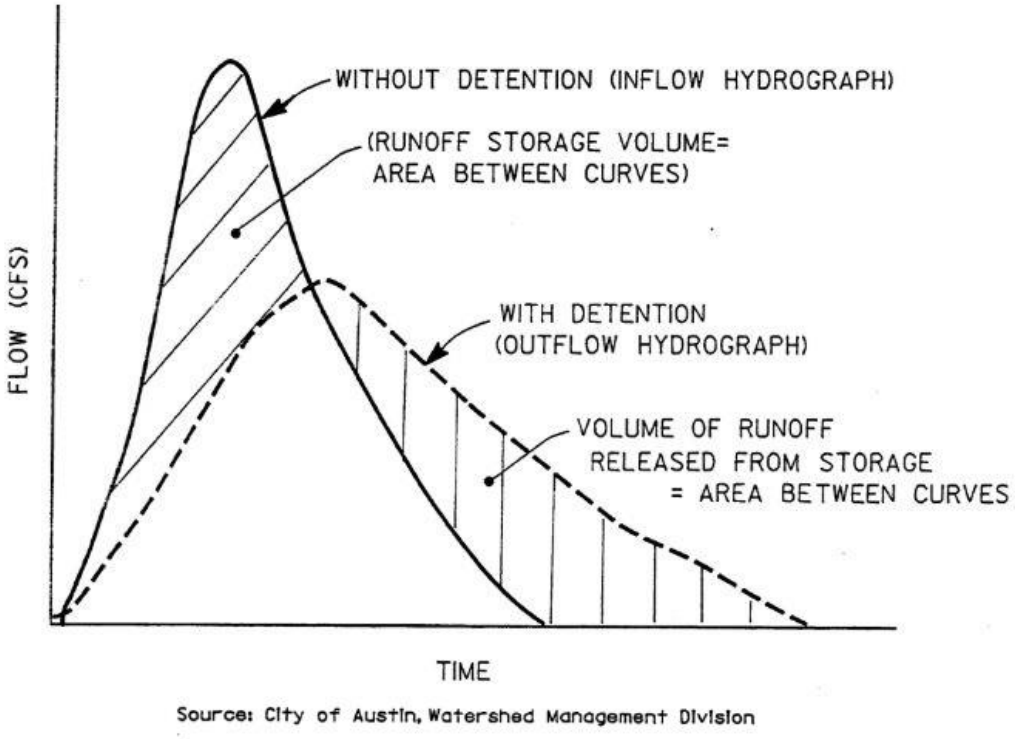


Figure 3 - Concept of Detention Pond

2. Peak Flow Requirements.

   A. Existing condition peak flows generated from the 25-year and 100-year frequency storm events shall not be increased.

B. The peak flows from the proposed site development for a 25-year storm and a 100-year storm shall be detained in on-site stormwater detention basins with release rates equal to, or less than, the flows generated in the site's existing condition.

C. Detention ponds must also include an engineered outfall structure that is designed in such a manner that the 100-year storm will pass and safely discharge the 100-year storm without damage to the downstream property or the detention pond's embankment.

D. Stormwater runoff peak flow rates shall not be increased at any point of discharge for the 25- and 100-year frequency storm events.

3. Structure Requirements.

A. All ponds shall meet or exceed all specified safety criteria. Use of these criteria shall in no way relieve the engineer of the responsibility for the adequacy and safety of all aspects of the design of the detention pond.

B. The spillway, embankment, and appurtenant structures shall be designed to safely pass the 100-year storm with freeboard equivalent to one (1) foot or ten (10%) percent of design capacity, whichever is less.

i. Any orifice with a dimension smaller than or equal to twelve (12) inches shall be assumed to be fully blocked for the design of the 100-year storm.

ii. For all spillways (especially enclosed conduits), the ability to adequately convey the design flows must take into account any submergence of the outlet, any existing or potential obstructions in the system and the capacity of the downstream system. For these reasons, enclosed conduit spillways connecting directly to other enclosed conduit systems are discouraged. If used, they must be justified by a rigorous analysis of all enclosed conduit systems connected to the spillway.

C. If an embankment is classified as a dam pursuant to Title 30, Part 1, Chapter 299, Texas Administrative Code, V.T.C.A. all design criteria found in Title 30, Part 1, Chapter 299, Texas Administrative Code, V.T.C.A. must be met, as evidenced by certification by an engineer licensed in the State of Texas.

D. Earthen embankment.

i. Side slopes for earthen embankments shall be no steeper than four (4) horizontal to one (1) vertical. Slopes must be designed to resist erosion and to be stable in all conditions, and to be easily maintained.

ii. The constructed height of an earthen embankment shall be equal to the design height plus the amount necessary to ensure that the design height will be maintained once all settlement has taken place. This amount shall in no case be less than five (5) percent of the total fill height. All earthen embankments shall be compacted to ninety-five (95) percent of maximum density.

iii. Access Area. Detention ponds shall be designed with adequate area around the perimeter for access and maintenance.

iv. Access area shall be a minimum of seven (7) feet wide for ponds with depths of five (5) feet or less (back slopes included) and a minimum of ten (10) feet wide for ponds over five (5) feet deep or with back slopes in excess of five (5) feet high.

v. Access area shall not slope more than sixteen (16) percent (1:6 slope).

vi. Exceptions to this access area requirement can be approved by the City Engineer and Public Works Director in writing for privately maintained detention ponds that have at least one access point.

4. Detention Pond Design Requirements

A. A flow routing analysis using detailed hydrographs must be applied for all detention pond designs. The NRCS hydrologic methods (available in TR-20, TR-55, HEC-1, HEC HMS and the Hydrologic Engineering Center (HEC)) hydrologic methods may be used for areas of two hundred (200) acres or more. Use of the modified rational method is limited to drainage areas less than two hundred (200) acres.

B. Detailed hydraulic design calculations shall be provided for all detention ponds. Stage-discharge rating data shall be presented in tabular form with all discharge components, such as orifice, Weir, and outlet conduit flows, clearly indicated. Stage-storage table shall also be provided. In all cases, the effects of tailwater or other outlet control considerations should be included in the rating table calculations.

C. When designing ponds in series (i.e., when the discharge of one (1) becomes the inflow of another), the engineer must submit a hydrologic analysis which demonstrates the system's adequacy. This analysis must incorporate the construction of hydrographs for all inflow and outflow components.

D. Storm runoff may be detained within parking lots. However, the engineer should be aware of the inconvenience to both pedestrians and traffic. The location of ponding areas in a parking lot should be planned so that this condition is minimized. Stormwater ponding depths (for the 100-year storm) in parking lots are limited to a maximum of eight (8) inches in depth.

E. All pipes discharging from a detention pond into a public storm sewer system shall have a minimum diameter of eighteen (18) inches and shall be constructed of reinforced concrete. Other materials may be used with approval of City Engineer. In all cases, ease of maintenance and/or repair must be assured.

F. All concentrated flows into a detention pond shall be collected and conveyed into the pond in such a way as to prevent erosion of the side slopes. All outfalls into the pond shall be designed to be stable and nonerosive.

5. Outlet/Discharge Design.

A. General

i. No outlet discharge from detention from detention ponds shall be designed to discharge concentrated flow directly onto city streets. Such discharges shall be conveyed by a closed conduit to the nearest existing storm sewer.

a. If there is no existing storm sewer within three hundred (300) feet, the outlet design shall provide for a change in the discharge pattern from concentrated flow back to sheet flow, following as near as possible the direction of the gutter.

b. When not discharging directly onto a street, the outfall discharge shall match the existing flow pattern as closely as possible.

ii. All pipes discharging into a public storm sewer system shall have a minimum diameter of eighteen (18) inches and shall be constructed of reinforced concrete. Other materials may be used with approval of City Engineer. In all cases, ease of maintenance and/or repair must be assured.

iii. Control Structures

a. There are two (2) basic types of outlet control structures: orifices and weirs. See Figure 4 for illustrations.

(1) Orifices

Orifice flow equation:

$$\boldsymbol{Q = C_O \times A \times (2 \times g \times H)^{0.5}}$$ **Equation 5**

Where:

Q = Orifice flow, cubic feet per second

C_o = Orifice coefficient (**use 0.6**)

A = Orifice area, square feet

g = Gravitation constant, 32.2 feet/sec ^{2}

H = Head on orifice measured from centerline, feet

(2) Weirs

(A) Generally, if the crest thickness is more than sixty (60) percent of the nappe thickness, the Weir should be considered broad-crested. The coefficients for sharp-crested and broad-crested Weirs vary. The respective Weir and orifice flow equations are as follows:

(B) Rectangular Weir flow equation:

$$\boldsymbol{Q = C \times L \times H^{1.5}}$$ **Equation 6**

Where:

Q = Weir discharge, cubic feet per second

C = Weir coefficient

L = horizontal length, feet

H = Head on Weir, feet

(C) V-notch Weir flow equation:

$$Q = C_v \times \tan\frac{\theta}{2} \times H^{2.5}$$

Equation 7

Where:

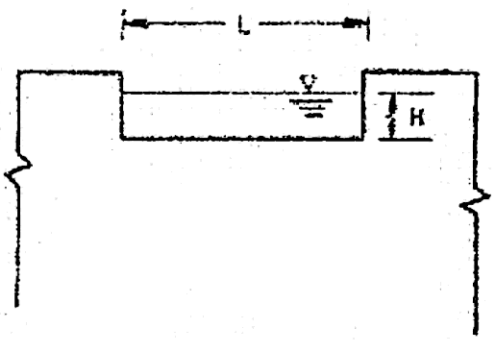
Q = Weir flow, cubic feet per second

C_v = Weir coefficient

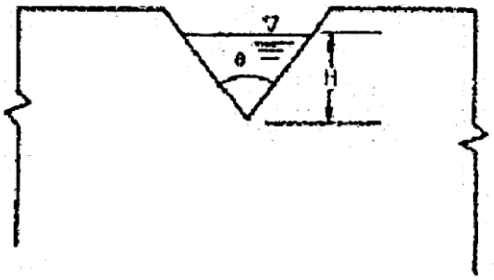
Θ = Angle of the Weir notch at the apex (degrees)

H = Head on Weir, feet

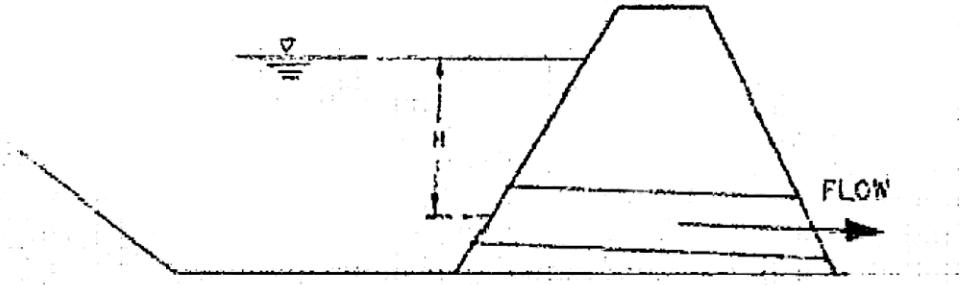
b. Analytical methods and equations for other types of structures shall be approved by the City Engineer prior to use. In all cases, the effects of tailwater or other outlet control considerations should be included in the rating table calculations.



RETANGULAR WEIR



V-NOTCH WEIR



ORIFICE DESIGN

Figure 4 - Weir and Orifice Diagrams

6. Detention Pond Exceptions.

   A. The City Engineer shall have the authority to waive the requirement for onsite detention, provided that at least one (1) of the following conditions are met:

      i. The development is adjacent to a defined water course that has sufficient capacity to convey the site's post-developed peak discharge from the 100-year storm event without creating an adverse impact on any other properties.

      ii. The development is located such that onsite detention may worsen downstream conditions of the watershed. In such cases, the engineer shall demonstrate that conveyance or a combination of detention and conveyance will provide a safer downstream condition.

      iii. It can be demonstrated that the post-developed impervious area is equal to or less than the pre-developed impervious area. Impervious area shall consist of concrete, asphalt, and/or building surfaces.

Subsection IV - Street Flow

1. General.

   A. Design Storm Frequency.

      i. The location of inlets and permissible flow of water in streets should be related to the extent and frequency of interference to traffic and the likelihood of flood damage to surrounding property for the 10- and 100-year frequency storms.

      ii. Street curbs, gutters, inlets and storm sewers shall be designed to intercept, contain and transport all runoff from the 10-year frequency storm, without overtopping the curb.

      iii. Conveyance provisions for the 100-year storm must also be made within defined right-of-way and easements.

   B. Drainage flow in streets.

      i. No concentrated point discharges directly into streets will be allowed unless approved by the City Engineer.

      ii. No lowering of the standard height of street crown shall be allowed for the purposes of obtaining additional hydraulic capacity.

   C. Interference due to flow in streets.

      i. Water which flows in a street, whether from rainfall directly onto the pavement surface or overland flow entering from adjacent land areas, will flow in the gutters of the street until it reaches an overflow point or some outlet, such as a storm sewer inlet. As the flow progresses downhill and additional areas contribute to the runoff, the width of flow will increase and progressively encroach into the traffic lane. On streets where parking is not permitted, as with many arterial streets, flow widths exceeding one (1) traffic lane become a traffic hazard. Field observations show that vehicles will crowd adjacent lanes to avoid curb flow.

      ii. As the width of flow increases, it becomes impossible for vehicles to operate without moving through water in an inundated lane. Splash from vehicles traveling in the inundated lane obscures the vision of drivers of vehicles moving at a higher rate of speed in the open lane. Eventually, if width and depth of flow become great enough, the street loses its effectiveness as a traffic-carrier. During these periods, it is imperative that emergency vehicles such as fire trucks, ambulances and police cars be able to traverse the street by moving along the crown of the roadway.

   D. Interference due to ponding. Storm runoff ponded on the street surface because of grade changes or because of the crown slope of intersecting streets has a substantial effect on the street-carrying capacity. The way ponded water affects traffic is essentially the same as for curb flow; that is, the width of spread into the traffic lane is critical. Ponded water will often completely halt all traffic. Ponding in streets has the added hazard of surprise to drivers of moving vehicles, producing erratic and dangerous responses.

   E. Street cross flow. Whenever storm runoff, other than limited sheet flow, moves across a traffic lane a serious and dangerous impediment to traffic flow occurs.

i. Cross flow is allowed only in case of superelevation of a curve or overflow from the higher gutter on a street with cross fall.

ii. No more than three (3) cubic feet per second for the 10-year storm shall be allowed to cross flow from the higher elevation to the lower elevation.

iii. On residential streets, flow exceeding 3 cfs will not be allowed unless concentrated in a valley gutter and limited to a maximum depth of 6 inches.

F. Allowable flow of water through intersections. For a residential street, the depth of flow across the intersection will not exceed 6 inches and will be contained in a valley gutter. For collectors and higher streets, no more than 3 cfs shall be allowed to cross the intersection. In both situations the inlet cannot be placed inside the curb return.

G. Valley gutter. Concrete valley gutters are useful in diminishing the deterioration of pavements, at intersections where slope across the intersection is less than one (1) percent.

i. At the intersection of two (2) arterial streets, a valley gutter cannot be used.

ii. At the intersection of two (2) collector streets or local streets, a valley gutter shall be installed when slope across the intersection is less than one (1) percent.

iii. At an intersection of two (2) different types of streets, the valley gutter may be used across the smaller street only.

2. Permissible Spread of Water.

A. The flow of water in gutters of various streets of different categories shall be limited by those values found on Table 6. These clear widths at the crown of the roadway or at the high point on a divided roadway are necessary to provide access for vehicles in the event of an emergency.

Table 6 - Minimum Clear Widths for Roadway Design Due to Gutter Flow

Roadway Type	Proposed Usage	Minimum Clear Width (Feet)
1. Local street	Residential	0
	Commercial/industrial	0
2. Collector	Minor	8
	Commercial/industrial	12
	Major:	
	4 Lanes	24
	5 Lanes	24
	4 Lanes divided	12 (each way)
	6 Lanes divided	12 (each way)
3. Arterial	4 Lanes, undivided	24
	3 Lanes, one-way	12
	4 Lanes, one-way	24
	4 Lanes, with continuous left turn lane	24
	4 Lanes, divided	12 (each way)
	6 Lanes, divided	12 (each way)
	8 Lanes, divided	24 (each way)

3. Design Method.

   A. Gutter flow velocities. To ensure scouring velocities for low flows, the gutter shall have a minimum slope in accordance with the Street Design Criteria Manual.

   B. Straight crowns. Flow in gutters on straight crown pavements is normally assumed to be uniform, with Manning's equation being used to determine the flow. However, because the hydraulic radius assumption in the Manning's equation is not able to adequately describe the hydraulic characteristics of the gutter cross section, modification of the equation is necessary to accurately compute the flow. The modified Manning's equation is:

$$\boldsymbol{Q_O = 0.56 \times \left(\frac{Z}{n}\right) \times S_O^{1/2} \times Y_O^{8/3}}$$

Equation 8

Where:

Q_0 = Gutter discharge, cfs

Z = Reciprocal of the crown slope, ft/ft

S_o = Street or gutter slope, ft/ft

n = Roughness coefficient

Y_o = Depth of flow in gutter, feet

   C. Parabolic crowns.

      i. Flows in the gutter of a parabolically crowned pavement are calculated from a variation of Manning's equation, which assumes steady flow in a prismatic open channel. However, this equation is complicated and difficult to solve for each design case.

To provide a means of determining the flow in the gutter, generalized gutter flow equations for combinations of parabolic crown heights, curb splits and street grades of different street widths have been prepared. All of these equations have a logarithmic form.

Note: The street width used in this section is measured from face of curb to face of curb.

ii. Streets without curb split. Curb split is the vertical difference in elevation between curbs at a given street cross section. The gutter flow equation for parabolic crown streets without any curb split is:

$$\log Q_0 = K_0 + K_1 \times \log S_0 + K_2 \times \log Y_0$$ **Equation 9**

Where:

Q_0 = Gutter flow, cfs

S_O = Street grade, ft/ft

Y_O = Water depth in the gutter, feet

K_0, K_1 , K_2 = Constant coefficients shown in Table 9 for different street widths:

Table 7 – Coefficients for Streets Without Curb Split Equation (Equation 9)

Street Width (ft)	Coefficients		
	K_0	K_1	K_2
30	2.85	0.50	3.03
36	2.89	0.50	2.99
40	2.85	0.50	2.89
44	2.84	0.50	2.83
48	2.83	0.50	2.78
60	2.85	0.50	2.74

Source: City of Austin, Watershed Engineering Division

iii. Streets with curb split—Higher gutter. The gutter flow equation for calculating the higher gutter flows is as follows:

$$\log Q_0 = K_0 + K_1 \times \log S_0 + K_2 \times \log Y_0 + K_3 \times C_S$$ **Equation 10**

Where:

Q = Gutter flow, cfs

S_0 = Street grade, ft/ft

y_0 = Water depth in the gutter, feet

C_S = Curb split, feet

K_0, K_1, K_2, K_3 = Constant coefficients shown in Table 10 for different street widths:

Table 8 - Coefficients for Streets with Curb Split - Higher Gutter Equation (Equation 10)

Street Width (ft)	Coefficients				Curb Split Range (ft)
	K_0	K_1	K_2	K_3	
30	2.85	0.50	3.03	-0.131	0.0—0.6
36	2.89	0.50	2.99	-0.140	0.0—0.8
40	2.85	0.50	2.89	-0.084	0.0—0.8
44	2.84	0.50	2.83	-0.091	0.0—0.9
48	2.83	0.50	2.78	-0.095	0.0—1.0
60	2.85	0.50	2.74	-0.043	0.0—1.2

Source: City of Austin, Watershed Engineering Division

iv. Streets with curb split—Lower gutter. The gutter flow equation for the lower gutter is:

$$\log Q_0 = K_0 + K_1 \times \log S_0 + K_2 \times \log Y_0 + K_3 \times C_S \quad \textbf{Equation 11}$$

Where:

Q = Gutter flow, cfs

S_0 = Street grade in ft/ft

y_0 = Water depth in the gutter in feet

C_S = Curb split in feet

K_0, K_1, K_2, K_3 = Constant coefficients shown in Table 9 for different street widths:

Table 9 - Coefficients for Streets with Curb Split - Lower Gutter Equation (Equation 11)

Street Width (ft)	Coefficients				Curb Split Range (ft)
	K_0	K_1	K_2	K_3	
30	2.70	0.50	2.74	-0.215	0.0-0.6
36	2.74	0.50	2.73	-0.214	0.0-0.8
40	2.75	0.50	2.73	-0.198	0.0-0.8
44	2.76	0.50	2.73	-0.186	0.0-0.9
48	2.77	0.50	2.72	-0.175	0.0-1.0
60	2.80	0.50	2.71	-0.159	0.0-1.2

Source: City of Austin, Watershed Engineering Division

v. Parabolic crown location. The gutter flow equation presented for parabolic crowns with split curb heights is based on a procedure for locating the street crown. The procedure allows the street crown to shift from the street center line toward the high one-fourth-percent point of the street in direct proportion to the amount of curb split. The maximum curb split occurs with the crown at the one-fourth-percent point of the street. The maximum allowable curb split for a street with parabolic crowns is 0.02 feet per foot of street width.

vi. Curb splits that are determined by field survey, whether built intentionally or not, should be considered when determining the capacity of the curb flow.

vii. Special consideration should be given when working with cross sections which have the pavement crown above the top of curb. When the crown exceeds the height of the curb the maximum depth of water is equal to the height of the curb, not the crown height. It

should be noted that a parabolic section where the crown equals the top of curb will carry more water than a section which has the crown one (1) inch above the top of curb.

Subsection V - Underground Stormwater Systems

1. General

    A. The public drainage system shall be designed to convey those flows from greater than the 10-year frequency storm up to and including the 100-year frequency storm within defined public rights-of-way or drainage easements.

    B. Storm drains between lots (crossing blocks) shall be avoided as much as possible. When unavoidable, the means of stormwater conveyance shall be laid along an alignment that retains the means of stormwater conveyance within the dedicated drainage easement.

    C. Storm drains along rear of residential lots (through back yards) shall not be permitted, unless approved in writing by City Engineer and Public Works Director, such approval not to be granted unless running storm drain through the rear of a residential lot is due to topography and storm drain is placed underground.

    D. Easements

        i. Easements for underground stormwater conveyance shall be a minimum of fifteen (15) feet in width or one and one-half (1½) times the depth of the storm drain, whichever is greater.

        ii. Easement width for above-ground stormwater conveyance shall be a minimum of the width of the channel to include adequate access for maintenance into and along the channel.

        iii. Fences may cross easements with underground facilities but may not run parallel. Fences may not cross or run parallel within drainage easements designed for surface flow.

2. Inlets

    A. General Requirements

        i. The primary purpose of storm drain inlets is to intercept excess surface runoff and deposit it in a drainage system, thus reducing the possibility of surface flooding.

        ii. The most common location for inlets is in streets which collect and channelize surface flow, making it convenient to intercept. Because the primary purpose of streets is to carry vehicular traffic, inlets must be designed so as not to conflict with that purpose.

        iii. The following guidelines shall be used in the design of inlets to be located in streets:

            a. Grated curb inlets are discouraged from use due to their increased tendency to clog and problems with replacement. In all instances where a curb inlet can be used in lieu of a grated curb inlet, it shall be required unless approval is given from the City Engineer.

            b. Minimum transition for recessed inlets shall be ten (10) feet.

            c. All curb inlets (whether in a sump or on grade) incorporate a standard five-inch depression. Unless otherwise approved in writing by City Engineer, all curb inlets shall be a minimum of ten (10) feet in length.

d. When recessed inlets are used, they shall not decrease the width of the sidewalk. Also, it should be noted that the use of recessed inlets must be approved by the City Engineer for all streets.

e. Design and location of inlets shall take into consideration pedestrian and bicycle traffic. In particular, grate inlets shall be designed to assure safe passage of bicycles.

f. Inlet design and location must be compatible with the following:

(1) Storm sewer inlets and gutter transitions shall be designed to avoid future driveways and to avoid conflicts with standard water and wastewater service locations;

(2) No utilities shall be allowed to cross through a storm sewer inlet or culvert; and

(3) No utilities shall be allowed to cross under a storm sewer inlet without written approval from the Public Works Director and City Engineer.

g. The use of slotted drains is discouraged except in instances where there is no alternative. If used, the manufacturer's design guidelines should be followed.

B. Inlet Classifications.

i. Inlets are classified into two (2) major groups: (1) inlets in sumps where flow contributes from two (2) or more sides (Type S); and (2) inlets on grade (Type G). The following list references the various inlet types (See Figure 5 through Figure 11).

Table 10 - Inlets in Sumps and on Grade

Inlets in Sumps	
(1) Curb opening	Type S-1
(2) Grate *	Type S-2
(3) Combination (grate and curb opening) *	Type S-3
(4) Area without grate	Type S-4
Inlets on Grade	
(1) Curb opening	Type G-1
(2) Grate *	Type G-2
(3) Combination (grate and curb opening) *	Type G-3

Recessed inlets are identified by the suffix (R), i.e.: S-1(R).

* For the flow capacity through the grate inlets, the engineer should check appropriate vendor catalog.

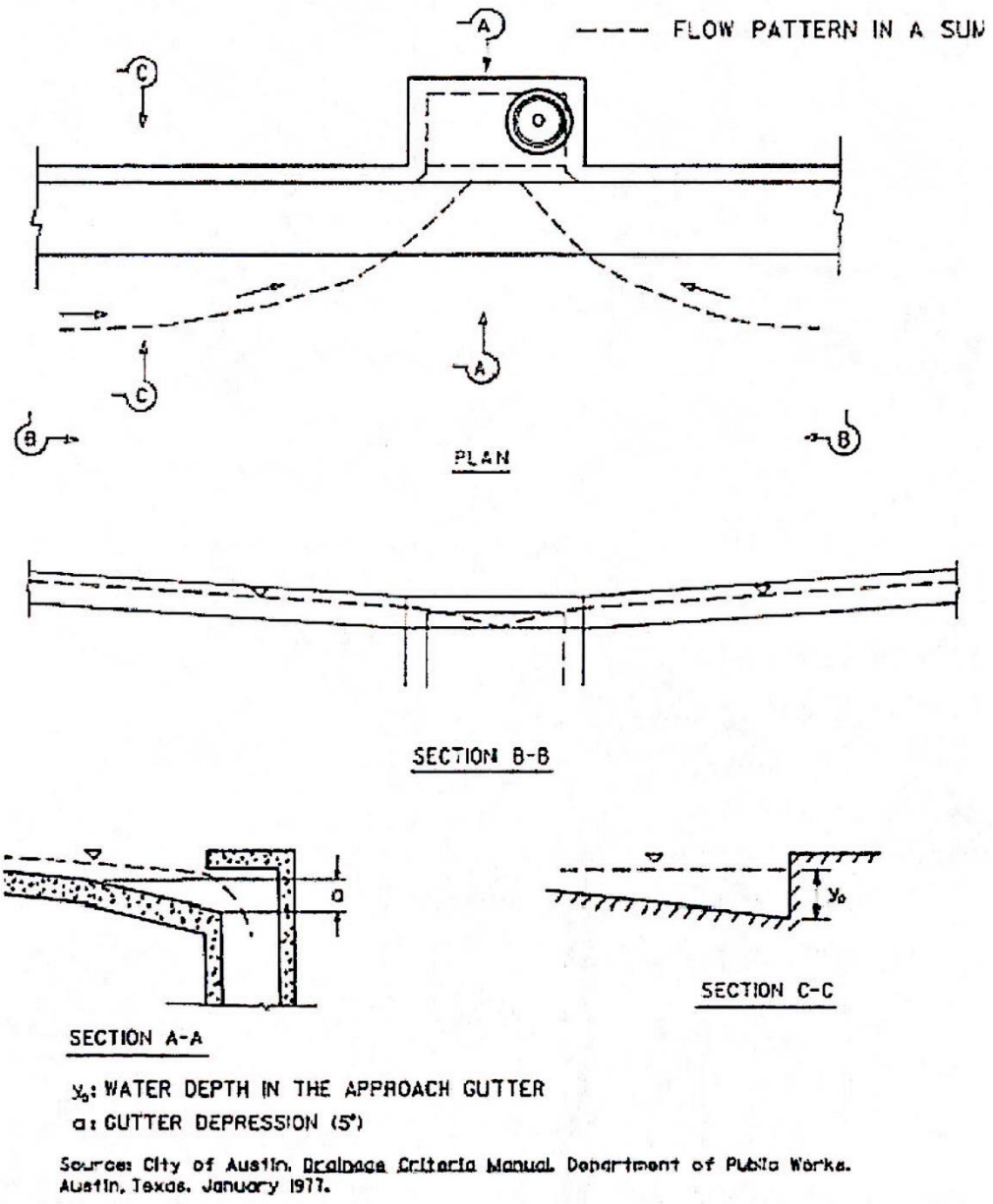
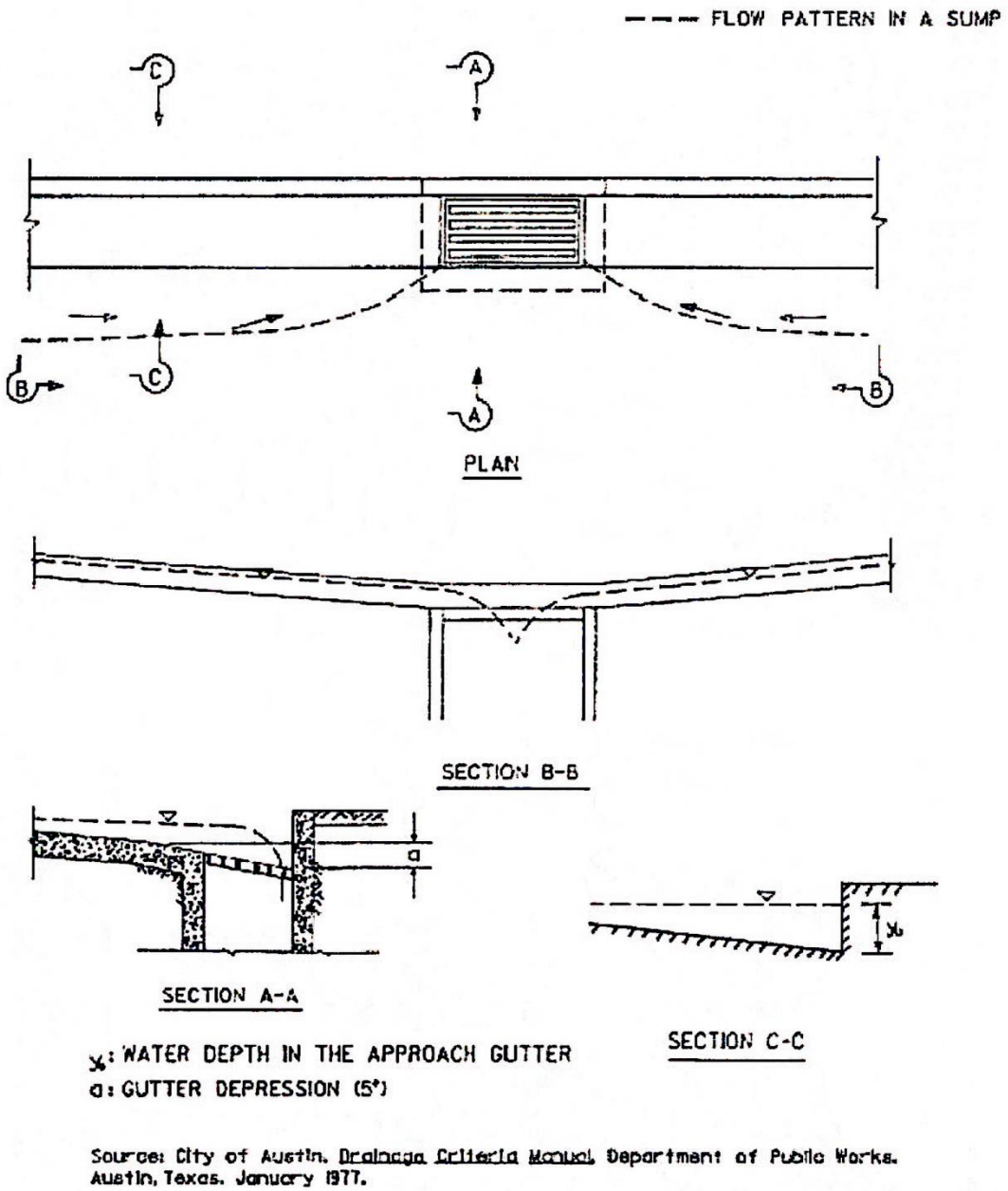
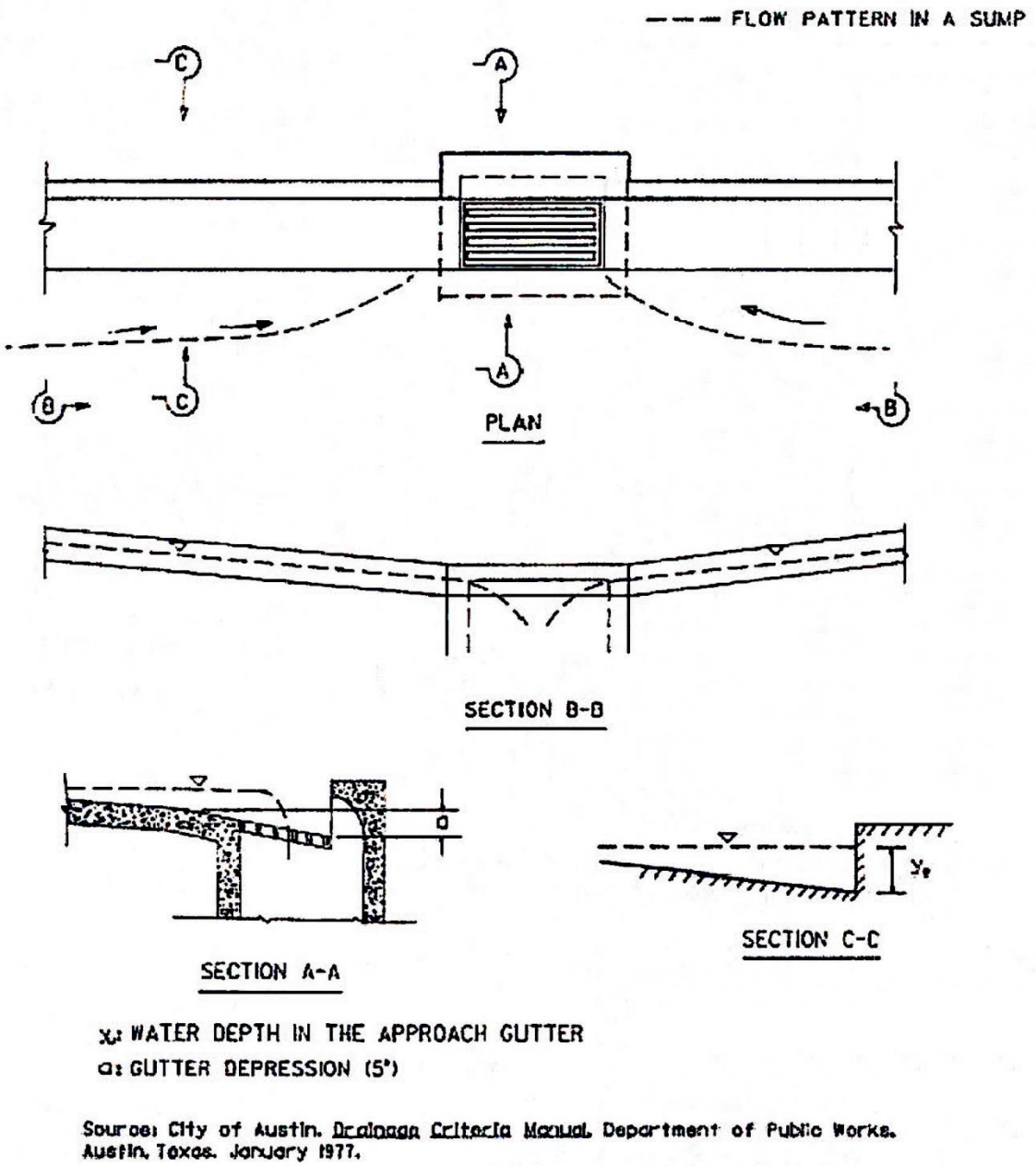


Figure 5 - Curb Opening Inlet in a Sump (Type S-1)



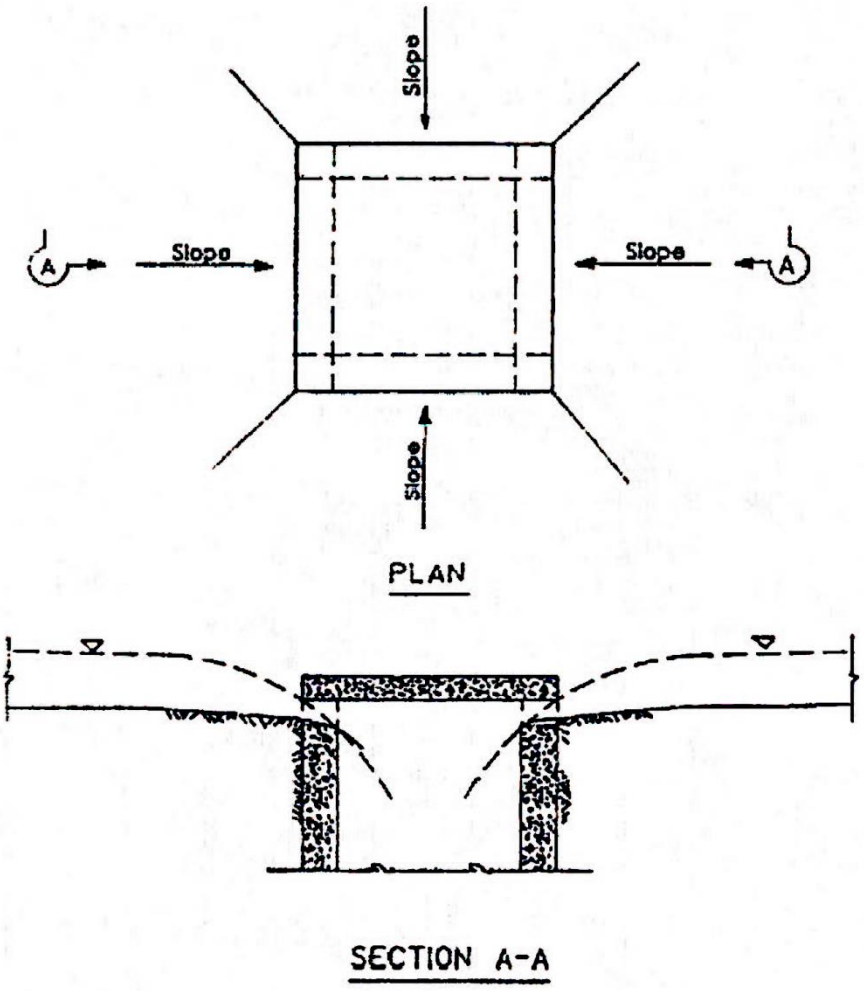
Source: City of Austin, Drainage Criteria Manual, Department of Public Works. Austin, Texas. January 1977.

Figure 6 - Grate Inlet in a Sump (Type S-2)



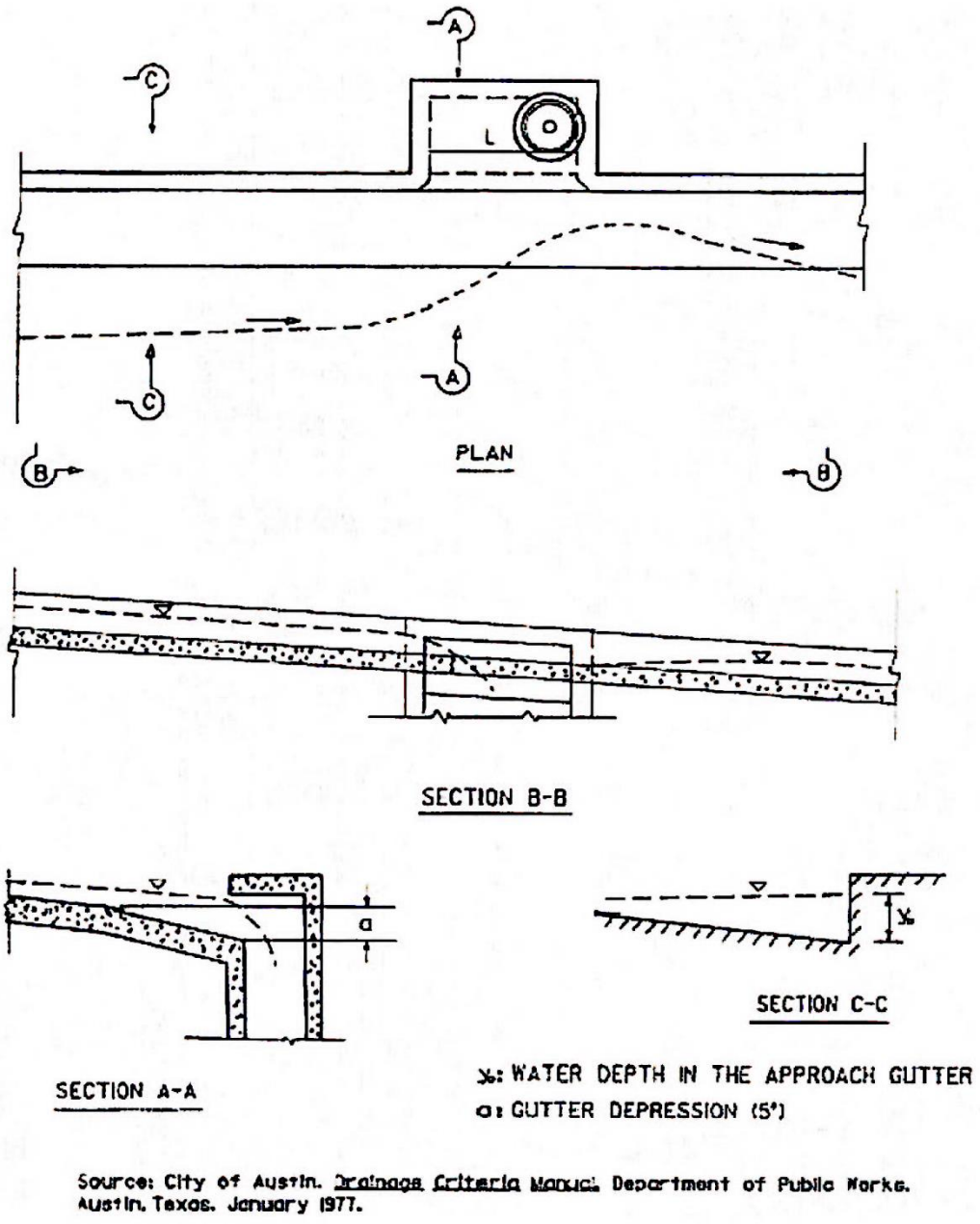
Source: City of Austin. Drainage Criteria Manual. Department of Public Works. Austin, Texas. January 1977.

Figure 7 - Combination Inlet in a Sump (Type S-3)



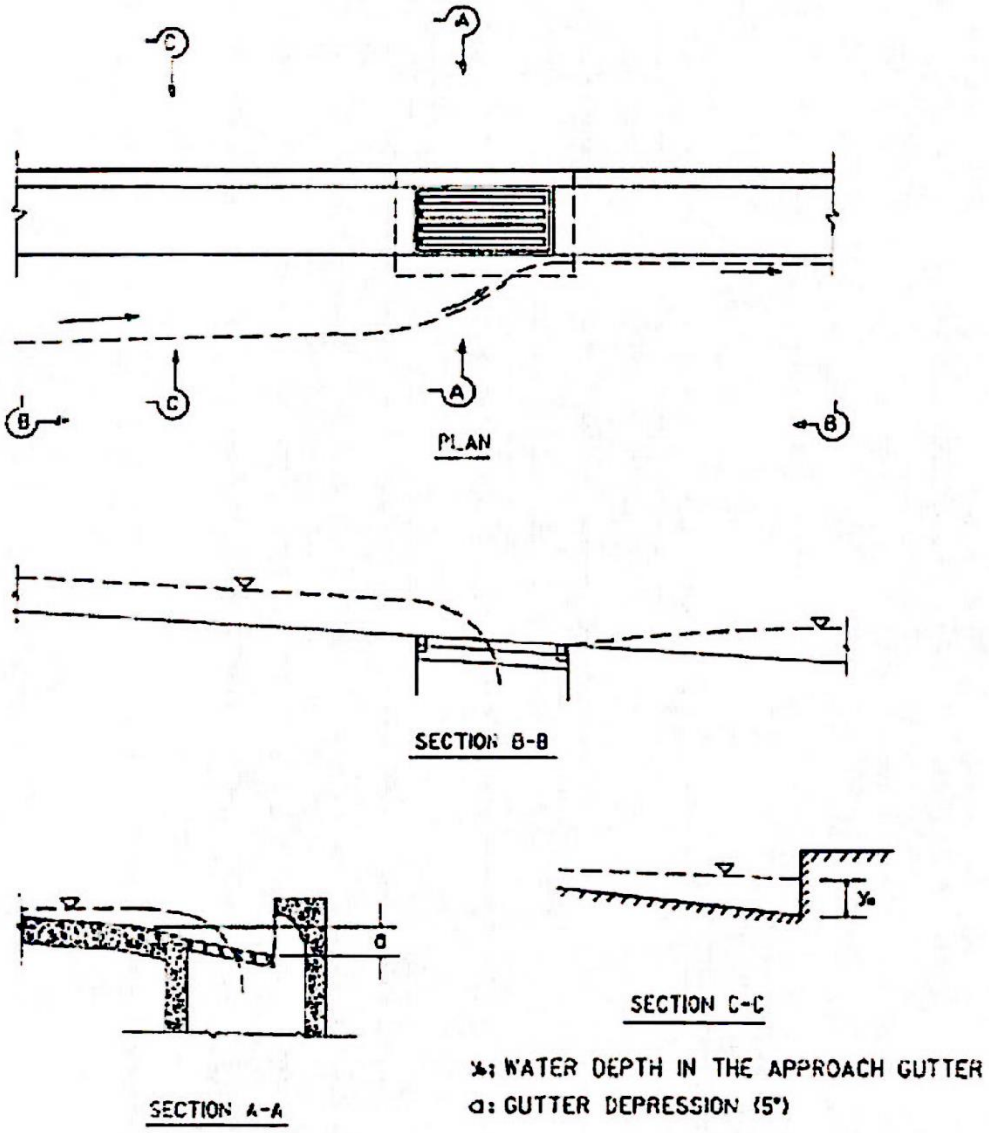
Source: City of Austin. Drainage Criteria Manual. Department of Public Works. Austin, Texas. January 1977.

Figure 8 - Area Inlet Without Grate (Type S-4)



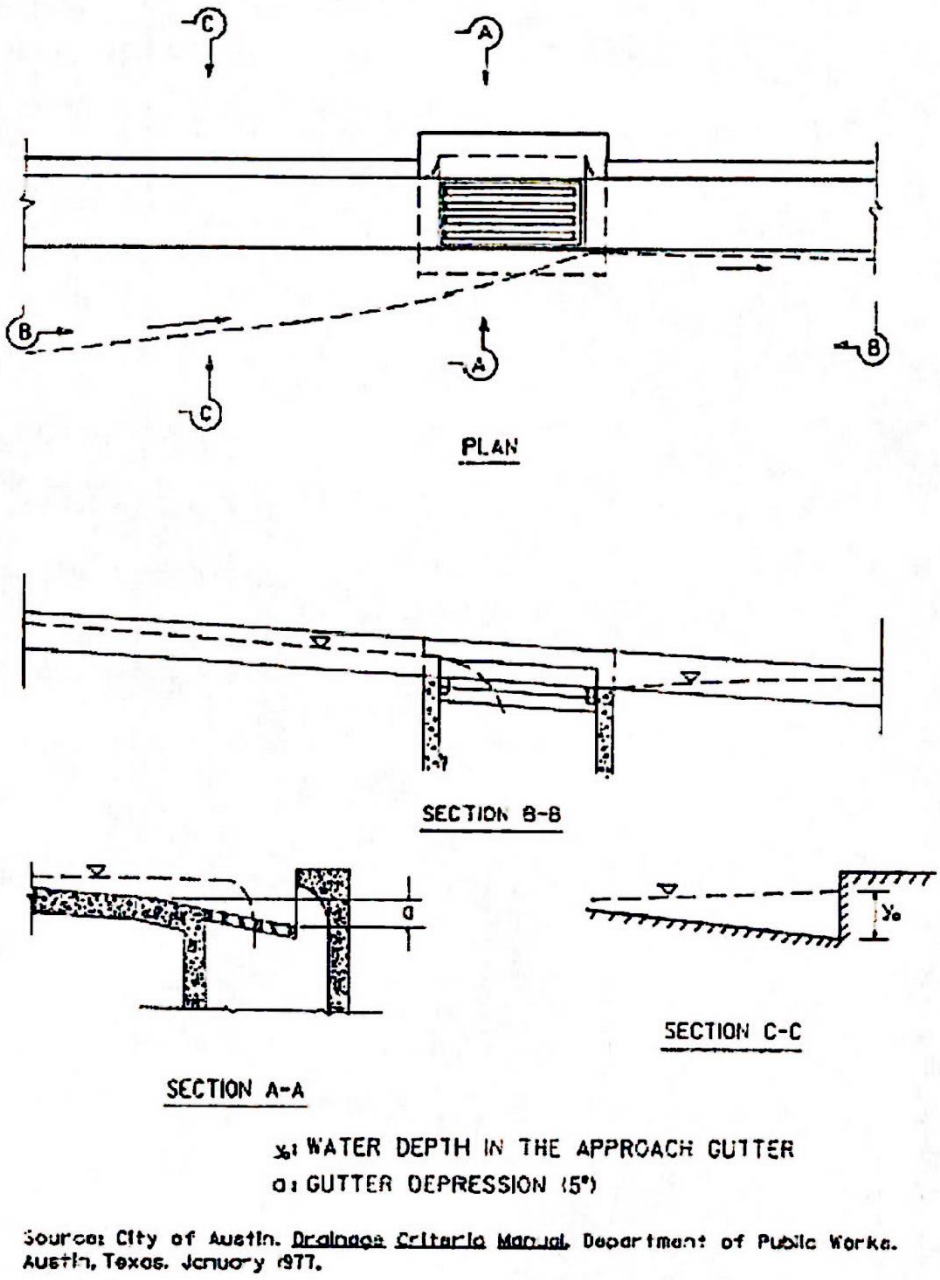
Source: City of Austin. Drainage Criteria Manual. Department of Public Works. Austin, Texas. January 1977.

Figure 9 - Curb Opening, Inlet on Grade (Type G-1)



Source: City of Austin, Drainage Criteria Manual, Department of Public Works, Austin, Texas, January 1977.

Figure 10 - Grate Inlet on Grade (Type G-2)



Source: City of Austin. Drainage Criteria Manual. Department of Public Works. Austin, Texas. January 1977.

Figure 11 - Combination Inlet on Grade (Type G-3)

C. Storm Inlet Hydraulics.

i. Inlets in sumps. Inlets in sumps are inlets at low points with gutter flow contributing from two (2) or more sides. The capacity of inlets in sumps must be known in order to determine the depth and width of ponding for a given discharge.

a. Curb opening inlets (Type S-1) and area inlet without grate (Type S-4). Unsubmerged curb opening inlets (Type S-1) and area inlets without grates (Type S-4) in a sump function as rectangular Weirs with a coefficient of discharge of 3.0. Their capacity shall be based on the following equation:

$$Q = 3.0 \times h^{1.5} \times L$$ **Equation 12**

Where:

Q = Capacity of curb opening inlet or of area inlet, cfs

h = Head at the inlet, feet

L = Length of opening through which water enters the inlet, feet

Curb opening inlets and drop inlets in sumps have a tendency to collect debris at their entrances. For this reason, the calculated inlet capacity shall be reduced by ten (10) percent to allow for clogging.

b. Grate inlets (Type S-2). An area inlet with a grate (Type S-2) in a sump functions as an orifice with a coefficient of discharge of 0.60. Therefore, the orifice equation becomes:

$$Q = 4.82 \times h^{0.5} \times A$$ **Equation 13**

Where:

Q = Capacity, cfs

h = Depth of flow at inlet, feet

A = Area of grate opening, square feet

Area inlets with grates in sumps have a tendency to clog from debris which becomes trapped by the inlet. For this reason, the calculated inlet capacity of a grate inlet shall be reduced by fifty (50) percent to allow for clogging. Since the clogging problems require maintenance, grate inlets in sumps are discouraged.

c. Combination inlets (Type S-3).

(1) The capacity of a combination inlet Type S-3 consisting of a grate and curb opening in a sump shall be considered to be the sum of the capacities obtained from Equations 12 and 13 above. When the capacity of the gutter is not exceeded, the grate inlet accepts the major portion of the flow.

(2) Combination inlets in sumps have a tendency to clog and collect debris at their entrances. For this reason, the calculated inlet capacities shall be reduced by their respective percentages indicated previously (which are ten (10) percent for a curb opening and fifty (50) percent for grate inlets).

d. Recessed inlets in sumps. (Type S-1(R), Type S-3(R)). Recessed inlets can be either curb opening or combination types. The clogging factors shall remain the same for recessed or non-recessed inlets.

ii. Inlets on grade with gutter depression

a. Curb opening inlets on grade (Type G-1). The capacity of a depressed curb inlet should be determined by the appropriate calculations. Because the inlet is on a slope and there is no grate to catch debris, the majority of the debris will be carried downstream; therefore, no reduction for clogging is necessary.

b. Grate inlets on grade (Type G-2).

(1) The depression of the gutter at a grate inlet decreases the flow past the outside of the grate. The effect is the same as that caused by the depression of a curb inlet.

(2) The bar arrangements for grate inlets greatly affect the efficiency of the inlet. In order to determine the capacity of a grate inlet on grade, the appropriate vendor catalog should be checked.

(3) Grate inlets have a tendency to trap debris such as leaves, and paper being carried by the gutter flows. This causes traffic problems from ponding water and requires maintenance. A reduction factor of thirty (30) percent to allow for clogging should be applied.

c. Combination inlets on grade (Type G-3). Combination inlets (curb opening plus grate) have greater hydraulic capacity than curb opening inlets or grate inlets of the same length. Generally speaking, combination inlets are the most efficient of the three (3) types of inlets on grade presented in this article. The basic difference between a combination inlet and a grate inlet is that the curb opening receives the carry-over flow that passes between the curb and the grate. The reduction factor for clogging of this type of inlet shall be zero (0) percent for the curb opening and thirty-five (35) percent for the grate inlet.

d. Recessed inlets on grade (Type G-1R, G-3R). Capacities for recessed inlets on grade shall be calculated as 0.75 times the capacity for non-recessed inlets. The clogging factors shall remain the same for the various types of inlets.

3. Storm Drains

A. General.

i. The purpose of this section is to consider the hydraulic aspects of storm drains and their appurtenances in a storm drainage system. Hydraulically, storm drainage systems consist of conduits (open or enclosed) in which unsteady and nonuniform flow exists. The design storm shall be the 10-year storm with provisions made for the 100-year storm as noted in the first part of the Underground Stormwater Systems section.

ii. All bends, wyes and pipe size changes in storm sewers shall be prefabricated or shall occur at manholes/junction boxes. All alignment changes greater than forty-five (45) degrees shall occur at a manhole or junction box.

iii. Storm drain pipe, junction boxes, and manholes shall be constructed of the materials specified in the City's Standard Details and Specifications.

a. Storm Drains shall be reinforced concrete pipe (RCP) per the City Standard Details and Specifications. There shall be a minimum of two (2) feet of cover in unpaved areas and a minimum of one and five-tenths (1.5) feet of cover from bottom of the base/top of the subgrade in paved areas. The engineer shall provide design information to the engineering department as appropriate to demonstrate that class of pipe used is sufficient for the loading conditions in situations where

minimum cover cannot be met. Higher strength pipes shall be used where loadings warrant such.

b. The use of high-density polyethylene (HDPE) shall be allowed in unpaved areas outside of city streets. All cross-street storm drainage conduit shall be reinforced concrete pipe (RCP). Further requirements for the use of HDPE are in the City Standard Details and Specifications.

B. Design Guidelines.

i. The following rules are to be observed in the design of storm drain system components to be located in public right-of-way or public drainage easements in order to promote proper operation and to minimize maintenance of those systems:

a. Select pipe size and slope so that the velocity of flow will increase progressively or at least will not appreciably decrease at inlets, bends or other changes in geometry or configuration.

b. Do not discharge the contents of a larger pipe into a smaller one even though the capacity of the smaller pipe may be greater due to a steeper slope.

c. For all pipe junctions other than a manhole, the angle of intersection between any two (2) flow paths shall not be greater than forty-five (45) degrees. This includes discharges into box culverts and channels.

d. No proposed pipe having a diameter greater than fifty (50) percent of the minimum dimension of an existing box culvert shall be allowed to discharge into that box culvert. Exceptions must be justified by structural engineering analysis.

e. Pipe shall be reinforced concrete. Concrete pipe shall be manufactured and installed in compliance with the City of Copperas Cove—Standards for Public Works Construction.

f. The 10-year hydraulic grade line shall remain six (6) inches below the theoretical gutter flow line of inlets.

C. Design Parameters.

i. Minimum grades. Storm drains should operate with velocities of flow sufficient to prevent deposition of solid material. The controlling velocity is near the bottom of the conduit and is considerably less than the mean velocity. Storm drains should be designed to have a minimum velocity of two (2) feet per second (fps).

ii. Maximum velocities. Maximum velocities in conduits are important because of the possibility of excessive erosion of the storm drain pipe material. Table 13 lists the maximum velocities allowed.

Table 11 - Maximum Velocity in Storm Drains

Type	Maximum Permissible Velocity
Storm drains (inlet laterals)	No limit
Storm drains (trunk)	20 fps

iii. Minimum diameter. Pipes that are to become an integral part of the public storm sewer system shall have a minimum diameter of eighteen (18) inches.

iv. Roughness coefficients. The coefficients of roughness listed in Table 14 are for use in Manning's Equation (Equation 15).

Table 12 - Mannings Roughness Coefficients "n" for Storm Drains

Materials of Construction	Minimum Design Coefficient
Concrete	0.013
Corrugated-metal pipe	0.024
Plain or coated	
Paved invert (asphalt)	0.020
Plastic pipe	
Smooth	0.010
Perforated	0.020

D. Flow in Storm Drains.

i. All storm drains shall be designed by the application of the continuity equation and Manning's equation by direct solution of the equations as follows:

a. Flow equation method.

$$\boldsymbol{Q = V \times A}$$ **Equation 14**

And

$$\boldsymbol{Q = \frac{1.49}{n} \times A \times R^{2/3} \times S^{1/2}}$$ **Equation 15**

Where:

Q = Pipe Flow, cfs

A = Cross sectional area of flow, ft^2

V = Velocity of flow, ft/sec

n = Coefficient of roughness of pipe

R = Hydraulic radius, ft

S = Friction slope in pipe, ft/ft

The following equation is used to calculate the hydraulic radius:

$$\boldsymbol{R = \frac{A}{W_P}}$$ **Equation 16**

Where:

W_p = Wetted perimeter, ft

E. Hydraulic Gradient.

i. In storm drain systems flowing full, all losses of energy are a function of resistance of flow in pipes or by interference with flow patterns at junctions. These losses must be accounted for by their accumulation along the system from its tailwater elevation at the outlet to its upstream inlet. The purpose of determining head losses is to include these values in a progressive calculation of the hydraulic gradient. In this way, it is possible to determine the hydraulic gradient line which will exist along the storm drain system. The hydraulic gradient line shall be computed and plotted for all sections of a storm drain system flowing full or under pressure flow. The determination of friction loss and minor loss are important for these calculations.

ii. Friction losses. Friction loss is the energy required to overcome the roughness of the pipe and can be calculated using a variety of equations and methods. The following methods are acceptable for use in the City of Copperas Cove

a. TxDOT Hydraulic Design Manual

b. Federal Highway Administration – Urban Drainage Design Manual

iii. Minor losses. From the point at which stormwater enters the drainage system at the inlet until it discharges at the outlet, it encounters a variety of hydraulic structures such as manholes, bends, enlargements, contractions and other transitions. These structures will cause head losses which are called "minor head losses." The references outlined under Friction Losses, above, also provide direction and examples for calculating minor losses.

F. Manholes.

i. Manholes provide a very important access point for maintenance purposes.

a. Due to equipment restraints, every point within the storm drain must be a maximum of three hundred (300) feet from an access point.

b. Inlets and storm drain outfalls may be considered as access points for maintenance purposes.

c. Access points must provide a maintenance path within the storm drain that has no more than one (1) horizontal bend, with that bend having a deflection of no more than forty-five (45) degrees in the direction of the maintenance path, and no vertical bend with a deflection of greater than five (5) degrees. Storm drain slope adjustments of less than five (5) degrees are not subject to this requirement.

ii. Manholes shall also be located where two (2) or more laterals intersect the main line within five (5) feet of each other.

iii. Manholes shall also be placed at locations where changes in pipe size occur.

G. Depth of Cover.

i. The design of storm drains for areas that will or could receive vehicular traffic or that will be subject to other loading must be supported by structural engineering calculations or references to structural engineering standards.

4. Culverts

   A. General.

      i. The function of a drainage culvert is to pass the design storm flow without causing excessive backwater or overtopping of the structure and without creating excessive downstream velocities. The designer shall keep energy losses and discharge velocities within allowable limits when selecting a structure that will meet these requirements.

      ii. Construction plans for proposed reinforced concrete box culverts, bridges and related structures may be adaptations of the current Texas Department of Transportation (TxDOT) Standards.

      iii. Design Storm Requirements

         a. For bridges and culverts in residential streets, runoff from the 100-year frequency flow shall not produce a headwater elevation at the roadway greater than either six (6) inches above the roadway crown elevation or any top of upstream curb elevation, whichever is lower.

         b. For bridges and culverts in streets other than a residential street, runoff from the 100-year frequency storm shall not produce a headwater elevation at the roadway greater than three (3) inches above the roadway crown elevation or three (3) inches above any top of upstream curb elevation, whichever is lower.

   B. Culvert Headwalls.

      i. General.

         a. The normal functions of properly designed headwalls and endwalls are to anchor the culvert in order to prevent movement due to hydraulic and soil pressures, to control erosion and scour resulting from excessive velocities and turbulence and to prevent adjacent soil from sloughing into the waterway opening.

         b. All headwalls shall be constructed of reinforced concrete and may be either straight-parallel, flared or warped. They may or may not require aprons, as determined by site conditions.

         c. Headwalls should be aligned with the direction of the receiving flow when discharging into a waterway.

         d. Precast headwalls and endwalls may be used if all other criteria are satisfied; generally precast headwalls/endwalls are available for smaller culverts eighteen (18) and twenty-four (24) inches [in] diameter.

      ii. Conditions at entrance. The operating characteristics of a culvert may be completely changed by the shape or condition at the inlet or entrance. Therefore, design of culverts must involve consideration of energy head losses that may occur at the entrance. Entrance head losses may be determined using the following methods:

         a. TxDOT Hydraulic Design Manual

         b. Federal Highway Administration – Urban Drainage Design Manual

iii. Type of headwall. The headwalls will be designed in accordance with the City Standard Specifications and Details.

a. Parallel headwall.

(1) Approach velocities are low (below six (6) feet per second).

(2) Backwater pools are permitted.

b. Flared headwall.

(1) Approach velocities are between six (6) and ten (10) feet per second.

(2) Ample right-of-way or easement is available.

(3) The wings of flared walls should be located with respect to the direction of the approaching flow.

(4) Warped headwall. Approach velocities are between eight (8) and twenty (20) feet per second. Warped headwalls are effective with aprons to accelerate flow through the culvert.

c. Debris fins.

(1) For conditions where more than one (1) box culvert is required and the potential for restricting/obstructing debris is present upstream, the upstream face of the structure shall incorporate debris deflector fins to prevent debris buildup. For multiple-pipe situations installations of debris fins may be used but are not required.

(2) The debris fin is an extension of the interior walls of a multiple-box culvert. The wall thickness shall be designed to satisfy structural requirements and reduce impact and turbulence to the flow.

(3) A debris fin is constructed to the height of the culvert. A fin length of one and five-tenths (1.5) times the height of the box culvert is required. Since the debris fins are subject to the same erosive forces as bridge piers, care must be taken in the design of the footing. A toewall at the upstream end of the debris fin and the apron is recommended. Figure 12 depicts the conceptual design for debris deflector fins. It should be noted that alternate types of wingwalls can be used other than the parallel shown in Figure 12.

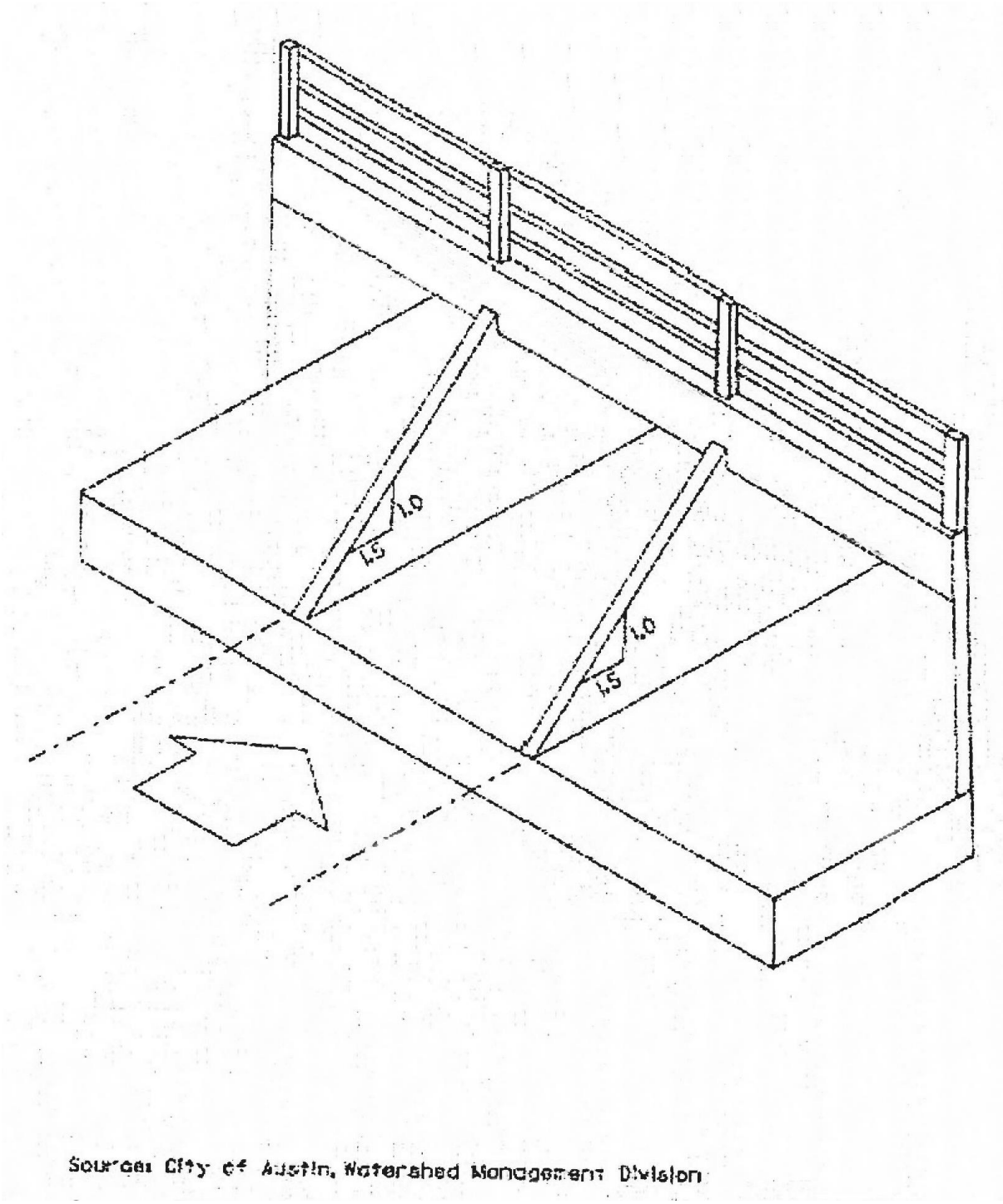


Figure 12 - Conceptual Design of Debris Fin

C. Culvert Discharge Velocities.

i. High discharge velocities from culverts can cause eddies or other turbulence which could damage unprotected downstream properties and roadway embankments. To

prevent damage from scour and erosion in these conditions, culvert outlet protection is needed. This outlet protection is based on the discharge velocity.

Table 13 - Culvert Outlet Protection Requirements

Velocity	Outlet Protection
Below six feet/second	Riprap protection. (Four-inch minimum thickness) or alternate approved material.
Above six feet/second	Structurally reinforced concrete apron, six-inch minimum thickness with toe wall.

ii. The minimum apron length which provides transition from a culvert outlet to an open channel shall be calculated from the following equation:

$$L = 0.2 \times V \times D$$ **Equation 17**

Where:

L = Apron length, feet

V = culvert discharge velocity, ft/sec

D = height of box culvert or diameter of pipe culvert, feet

D. Selection of Culvert Size and Flow Classification.

i. Culvert size and flow classification.

a. Laboratory tests and field observations show that there are two (2) major types of culvert flow: (1) flow with inlet control; and (2) flow with outlet control.

(1) Under inlet control, the cross-sectional area of the barrel, the inlet configuration or geometry and the amount of headwater are the factors affecting capacity. Also, the slope of the culvert is steep enough so that the culvert does not flow full and the tailwater does not affect the flow.

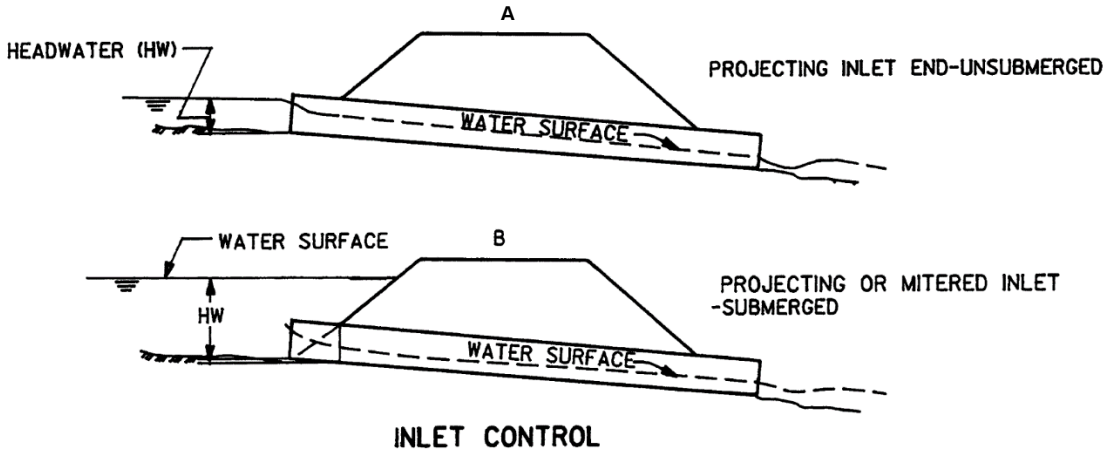
(2) Outlet control involves the additional consideration of the tailwater in the outlet channel and the slope, roughness and length of barrel.

ii. Culvert hydraulics.

a. Inlet control condition. Inlet control for culverts may occur in two (2) ways.

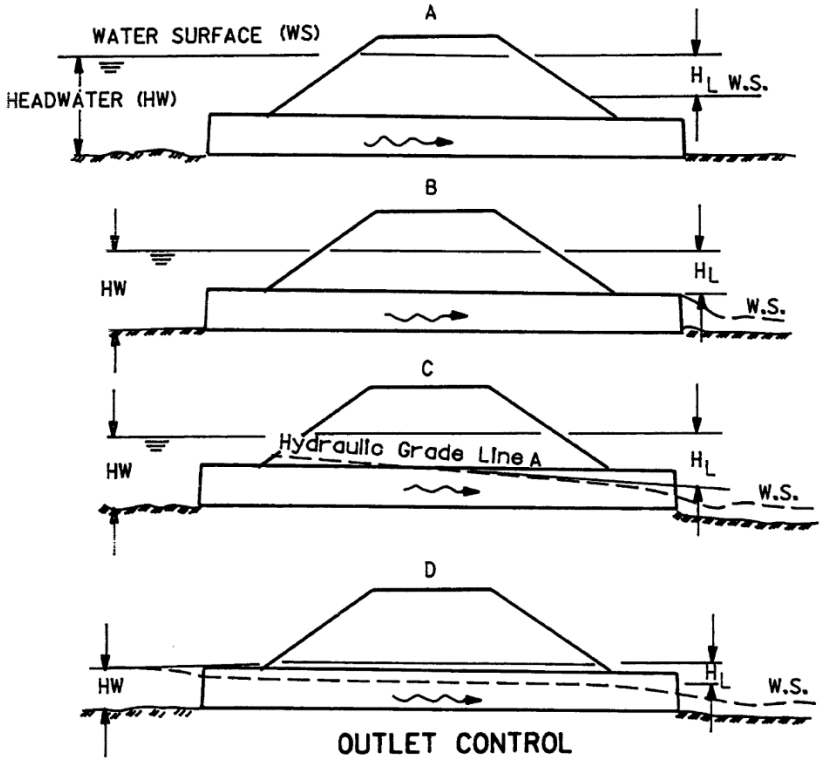
(1) Unsubmerqed. The headwater is not sufficient to submerge the top of the culvert opening and the culvert inlet slope is supercritical. The culvert inlet acts like a Weir (Condition A, Figure 13).

(2) Submerged. The headwater submerges the top of the culvert but the pipe does not flow full. The culvert inlet acts like an orifice (Condition B, Figure 13).



INLET CONTROL

INLET CONTROL IS ONE OF THE TWO MAJOR TYPES OF CULVERT FLOW. CONDITION A WITH AN UNSUBMERGED CULVERT INLET IS PREFERRED TO THE SUBMERGED END. SLOPE, ROUGHNESS AND LENGTH OF CULVERT BARREL ARE NOT A CONSIDERATION.



OUTLET CONTROL

OUTLET CONTROL INVOLVES THESE FACTORS: CROSS-SECTIONAL AREA OF BARREL, INLET "GEOMETRY", PONDING, SLOPE, ROUGHNESS, TAILWATER, AND LENGTH OF CULVERT BARREL.

Source: Boulder County, Storm Drainage Criteria Manual

Figure 13 - Inlet and Outlet Conditions for Culverts

b. Outlet control condition.

(1) There are three (3) types of outlet control culvert flow conditions:

(A) The headwater submerges the culvert opening, and the culvert outlet is submerged by the tailwater. The culvert will flow full (Condition A, Figure 13)

(B) The headwater submerges the culvert opening, the culvert outlet is not submerged by the tailwater (Condition B or C, Figure 13).

(C) The headwater is insufficient to submerge the top of the culvert opening. The culvert slope is subcritical and the tailwater depth is lower than critical depth for the culvert (Condition D, Figure 13).

c. Depths of tailwater and headwater.

(1) In culverts flowing with outlet control, tailwater is an important factor in computing both the headwater depth and the hydraulic capacity of a culvert. Thus, in many culvert designs, it becomes necessary to determine tailwater depth in the outlet channel.

(2) Much engineering judgment and experience are needed to evaluate possible tailwater conditions during storms. A field inspection should be made to check on downstream controls and to determine water stages. Tailwater is often controlled by a downstream obstruction or by water stages in another stream.

(3) An approximation of the depth of flow in a natural stream (outlet channel) can be made by using Manning's Equation (Equation 15) in the channel with normal flow condition. If the water surface in the outlet channel is established by downstream controls, a backwater analysis is required (see Open Channel Hydraulics Section).

(4) Design procedures. The State Highway Department's THYSYS program can be used for culvert design in addition to help calculate the culvert size and related computations.

E. Hydraulic considerations in bridge design.

i. General.

a. See Culverts Section in the Underground Stormwater Systems Section for design storm requirements for bridge structures.

(1) Several hydraulic parameters should be considered in bridge design. Among these considerations should be, but should not be limited to, the following:

(A) Channel transitions into and out of the bridge opening.

(B) Overall length and height of bridge.

(C) Cross sectional opening of bridge.

(D) Location of the bridge opening relative to the main channel.

(E) Bridge alignment relative to general flow of main channel i.e., "skewed" crossing.

(F) Number of crossings or bridge openings.

(G) Other obstructions to flow i.e., piers, abutments, deck width and clearances.

(H) Design flows for bridge opening to pass.

(I) Any freeboard requirements for channel design.

(2) A complete design guide and list of requirements for the design of bridge hydraulics can be found in the TxDOT Hydraulic Design Manual.

(A) A more thorough and complete discussion of these parameters and preliminary design procedures are presented in Chapters 1 and 11 of Hydraulics of Bridge Waterways by U.S. Department of Transportation Federal Highway Administration, Second Edition, September 1973.

(3) Modeling hydraulic conditions. The use of computer modeling for bridge hydraulic conditions is acceptable. A report containing assumptions, bridge design constraints, and appropriate documentation of results from the must be submitted for review by City Staff.

Subsection VI - Open Channels

1. General

   A. Open channels for use in a major drainage system have significant advantages related to cost, capacity, multiple use for recreational and aesthetic purposes and potential for detention storage. Disadvantages include right-of-way needs and maintenance costs. Careful planning and design are needed to minimize the disadvantages and to increase the benefits.

   B. The general classifications for open channels are: (1) natural channels, which include all watercourses that have been carved by nature through erosion; and (2) new or altered channels, which are constructed or existing channels that have been significantly altered by human effort. New or altered channels can be lined with grass, concrete, mortared rocks or other materials.

      i. Natural channels. The ideal natural channel has the following benefits:

         a. Velocities are usually low, resulting in longer concentration times and lower downstream peak flows.

         b. Maintenance needs are usually low because the channel is somewhat stabilized.

         c. The channel provides a desirable greenbelt and recreational area adding significant social benefits.

      ii. New or altered channels. Grass channels are the most desirable of the various types of new channels for the following reasons:

         a. The grass can stabilize the body of the channel.

         b. The grass consolidates the soil mass of the bed.

         c. The grass controls the movement of soil particles along the channel bottom.

      iii. Concrete lined channels. Concrete lined channels are designed to protect the channel body from the erosive potential of high velocities. In addition to concrete-lined channels, other methods to combat erosive velocities in channels may be available and should be submitted to the City Engineer for review.

   C. Access.

      i. Drainage Channels that are to be maintained by the City shall be contained within drainage easements

      ii. Adequate room for access shall be provided for drainage channels.

      iii. Ramps no steeper than five (5) feet horizontal to one (1) feet vertical shall be provided to allow access to drainage channels.

   D. Slope Protection

      i. Rip-rap for slope protection shall be per the City Standard Details and Specifications.

ii. Velocity dissipation shall be designed in accordance with these criteria and in such a manner to reduce the velocity so that downstream erosion is prevented.

E. Vegetation

i. All slopes shall be hydro-mulched, sodded or seeded with approved grass, grass mixtures or ground cover suitable to the area and season in which they are applied. Seeded side slopes and bottoms shall be lined with erosion protection matting, unless vegetation is established.

ii. All earthen channels must have vegetation established in accordance with the current TCEQ General Permit to Discharge Under the Texas Pollutant Discharge Elimination System (TPDES) – Permit No. TXR150000, with no bare spots greater than ten (10) square feet, prior to acceptance by the City of Copperas Cove.

iii. If vegetation cannot be adequately established prior to the desired acceptance date, up to three (3) months additional grow-in time may be granted by the City Engineer.

a. Such an extension must be requested in writing with details of the efforts to be taken to ensure adequate vegetation will be established within three (3) months.

b. Extension requests must also be accompanied by an irrevocable line of credit, surety, or maintenance bond equal to one hundred (100) percent of the cost to fully sod the entire area to be vegetated. This guarantee shall be separate from any other required maintenance bonds.

2. Open Channel Hydraulics.

A. An open channel is a conduit in which water flows with a free surface. The classification of open channel flow is made according to the change in flow depth with respect to time and space.

i. Flow in an open channel is said to be "steady" if the depth of flow does not change or if it can be assumed to be constant during the time interval under consideration. The flow is "unsteady" if the depth changes with time.

ii. Open channel flow is said to be "uniform" if the depth of flow is the same at every section of the channel. A uniform flow may theoretically be steady or unsteady, depending on whether or not the depth changes with time. The establishment of unsteady uniform flow requires that the water surface fluctuate with time while remaining parallel to the channel bottom. Since it is impossible for this condition to occur within a channel, steady uniform flow is the fundamental type of flow treated in open channel hydraulics.

iii. Flow is "varied" if the depth of flow changes along the length of the channel. Varied flow may be either steady or unsteady. Since unsteady uniform flow is rare, the term "unsteady flow" is used to designate unsteady varied flow exclusively.

iv. Varied flow may be further classified as either "rapidly" or "gradually" varied. The flow is rapidly varied if the depth changes abruptly over a comparatively short distance;

otherwise, it is gradually varied. Rapidly varied flow is also known as a local phenomenon; an example of which is the hydraulic jump.

v. With these varying conditions, open channel hydraulics can be very complex, encompassing many different flow conditions from steady uniform flow to unsteady rapidly varied flow. Most of the problems in stormwater drainage involve uniform, gradually varied or rapidly varied flow situations. In this section, the basic equation and computational procedures for uniform, gradually varied and rapidly varied flows are presented.

B. Uniform flow.

i. For a given channel condition of roughness, discharge and slope, there is only one (1) possible depth for maintaining a uniform flow. This depth is referred to as normal depth. See Mannings Equation in Equation 15 for calculation of uniform flow.

ii. Uniform flow is more often a theoretical abstraction than an actuality. True uniform flow is difficult to find in nature or to obtain in the laboratory. The engineer must be aware of the fact that uniform flow computations provide only an approximation of what will occur but that such computations are usually adequate and useful and, therefore, necessary for planning.

C. Gradually varied flow.

i. The most common example of gradually varied flow in urban drainage systems occurs in the backwater of bridge openings, culverts, storm sewer inlets and channel constrictions. Under these conditions, gradually varied flow will be created, and the flow depth will be greater than normal depth in the channel. Backwater techniques would need to be applied to determine the water surface profile.

ii. Calculations of water surface profiles can be accomplished by using standard backwater methods or acceptable computer routines, which take into consideration all losses due to changes in velocity, drops, bridge openings and other obstructions in open channels.

iii. There are several acceptable methods for backwater calculations. The most common hand calculation method for prismatic channels and irregular-uniform channels is the Standard Step Method. The most widely used backwater analysis computer program is HEC-RAS, developed by the U.S. Army Corps of Engineers. This program can compute water surface profiles for natural and new channels.

D. Rapidly varied flow. Rapidly varied flow is characterized by abrupt changes in the water surface elevation for a constant flow. The change in elevation may become so abrupt that the flow profile is virtually broken, resulting in a state of high turbulence. Some common causes of rapidly varied flow in urban drainage systems are side-spill Weirs, Weirs and spillways of detention basins.

E. Manning's Roughness Coefficients.

i. Existing and natural channels.

a. Because several primary factors affect the roughness coefficient, a procedure has been developed to estimate this value, n. By this procedure, the value of n may be computed by:

$$\boldsymbol{n = (n_0 + n_1 + n_2 + n_3 + n_4) \times m}$$ **Equation 18**

Where:

n_0 is a basic n value for a straight, uniform, smooth channel in the natural materials involved

n_1 is a value added to n 0 to correct for the effect of surface irregularities

n_2 is a value for variations in shape and size of the channel cross section

n_3 is a value for obstructions

n_4 is a value for vegetation and flow conditions

m is a correction factor for meandering of the channel

b. Proper values of n_0 to n_4 and m may be selected from Table 14 according to the given conditions

Table 14 - Composite Roughness Coefficient for Excavated and Natural Channels

Channel Conditions		**Values**
n_0 Material involved	Earth	0.020
	React	0.025
	Fine gravel	0.024
	Coarse gravel	0.028
n_1 Degree of irregularity	Smooth	0.000
	Minor	0.005
	Moderate	0.010
	Severe	0.020
n_2 Relative effect of channel cross section	Gradual	0.000
	Alternating occasionally	0.005
	Alternating frequently	0.013
n_3 Relative effect of obstructions	Negligible	0.000
	Minor	0.013
	Appreciable	0.025
	Severe	0.050
n_4 Vegetation	Low	0.008
	Medium	0.018
	High, very	0.038
	High	0.075
m Degree of meandering	Minor	1.000
	Appreciable	1.150
	Severe	1.300

Source: Chow, V.T. Open Channel Hydraulics, 1959.

c. In selecting the value of n_1 , the degree of irregularity is considered smooth for surfaces comparable to the best attainable for the materials involved; minor for good dredged channels, slightly eroded or scoured side slopes of canals or drainage

channels; moderate for fair to poor dredged channels, moderately sloughed or eroded side slopes of canals or drainage channels; and severe for badly sloughed banks of natural streams, badly eroded or sloughed sides of canals or drainage channels, and unshaped, jagged and irregular surfaces of channels excavated in rock.

d. In selecting the value of n_2 , the character of variations in size and shape of cross section is considered gradual when the change in size or shape occurs gradually; alternating occasionally when large and small sections alternate occasionally or when shape changes cause occasional shifting of main flow from side to side; and alternating frequently when large and small sections alternate frequently or when shape changes cause frequent shifting of main flow from side to side.

e. The selection of the value of n_3 is based on the presence and characteristics of obstructions such as debris deposits, stumps, exposed roots, boulders and fallen and lodged logs. One should recall that conditions considered in other steps must not be re-evaluated or double-counted in this selection. In judging the relative effect of obstructions, consider the following: the extent to which the obstructions occupy or reduce the average water area, the obstruction characteristics (sharp-edged or angular objects induce greater turbulence than curved, smooth-surfaced objects) and the position and spacing of obstructions transversely and longitudinally in the reach under consideration.

f. In selecting the value of n_4, the degree of effect of vegetation is considered in the following way:

   (1) Low for conditions comparable to the following: (a) dense growths of flexible turf grasses or weeds, of which Bermuda and blue grasses are examples, where the average depth of flow is two (2) to three (3) times the height of vegetation; and (b) supple seedling tree switches, such as willow, cottonwood or salt cedar where the average depth of flow is three (3) to four (4) times the height of the vegetation.

   (2) Medium for conditions comparable to the following: (a) turf grasses where the average depth of flow is one (1) to two (2) times the height of vegetation; and (b) stemmy grasses, weeds or tree seedlings with moderate cover where the average depth of flow is two (2) to three (3) times the height of vegetation and brush growths, moderately dense, similar to willows one (1) to two (2) years old, dormant season, alongside slopes of a channel with no significant vegetation along the channel bottom, where the hydraulic radius is greater than two (2) feet.

   (3) High for conditions comparable to the following: (a) turf grasses where the average depth of flow is about equal to the height of vegetation, (b) dormant season—willow or cottonwood trees eight (8) to ten (10) years old, intergrown with some weeds and brush, where none of the vegetation is in foliage, where the hydraulic radius is greater than two (2) feet; and (c) growing season—bushy willows about one (1) year old intergrown with some weeds in full foliage

alongside slopes, no significant vegetation along channel bottom, where hydraulic radius is greater than two (2) feet.

(4) Very high for conditions comparable to the following: (a) turf grasses where the average depth of flow is less than one-half (½) the height of vegetation, (b) growing season—bushy willows about one (1) year old, intergrown with weeds in full foliage alongside slopes, or dense growth of cattails along channel bottom, with any value of hydraulic radius up to ten (10) or fifteen (15) feet and (c) growing season-trees intergrown with weeds and brush, all in full foliage, with any value of hydraulic radius up to ten (10) or fifteen (15) feet.

g. In selecting the value of m, the degree of meandering depends on the ratio of the meander length to the straight length of the channel reach. The meandering is considered minor for ratios of one (1.0) to one and two-tenths (1.2), appreciable for ratios of one and two-tenths (1.2) to one and five-tenths (1.5), and severe for ratios of one and five-tenths (1.5) and greater.

h. In applying the above method for determining the n value, several things should be noted. The method does not consider the effect of suspended and bed loads. The values given in Table 15 were developed from a study of some forty (40) to fifty (50) cases of small and moderate channels. Therefore, the method is questionable when applied to large channels whose hydraulic radii exceed fifteen (15) feet. The method applies only to unlined natural streams, floodways, and drainage channels and shows a minimum value of 0.02 for the n value of such channels. The minimum value of n in general, however, may be as low as 0.012 in lined channels and as low as 0.008 in artificial laboratory flumes.

ii. New or altered channels. The Manning's roughness coefficients (n) for new or altered channels are shown in Table 15.

Table 15 - Minimum Roughness Coefficients of New or Altered Channels

Type of Channel and Description	Manning's Coefficients
1. Grass lined	
a. Bermuda (with regular mowing)	.040
b. St. Augustine (with regular mowing)	.045
c. Native grasses and vegetation not	.060
2. Concrete	
a. Concrete lined (rough finish)	.020
b. Concrete lined (smooth finish-culverts)	.015
c. Concrete rip-rap (exposed rubble)	.025
3. Gabion	.035
4. Rock-cut	.025

Source: 1. Chow, V.T. Open Channel Hydraulics. 1959.

WRC Engineering, Inc. Boulder County Storm Drainage Criteria Manual. 1984.

3. Design Requirements.

A. Design requirements. Channel design involves the determination of the channel cross section required to accommodate a given design discharge. The design requirements for

open channels are discussed in the sections below and apply to channels or waterways that are proposed to be modified or constructed.

B. Grass-lined channels and waterways. Key parameters in grass-lined channel or waterway design include permissible velocity, roughness coefficient, side slope, curvature, bottom width, and freeboard. The grass species selected shall be suitable for permanent application based upon the anticipated operation and maintenance of the channel or waterway.

   i. Velocity. The maximum permissible velocity for the 100-year storm is six (6) feet per second and includes all transitions to or from channels and waterways with similar or different materials. In all cases, the velocity for the 100-year storm must be non-erosive. The minimum permissible velocity for the two-year storm is two (2) feet per second.

   ii. Roughness coefficient. The roughness coefficients selected shall be based on the degree of retardance of vegetation. Table 17 provides minimum Manning's coefficients for channel design. The roughness coefficient shall be adjusted to reflect the relationship between the depth of flow and the typical height of the design vegetation, especially for shallow depths of flow, as well as other factors affecting channel conveyance.

      a. Slope. Slopes shall be such as to meet the requirements for the velocities stated in 1. Above.

      b. Side slopes. Side slopes shall be four (4) to one (1) or flatter for channels equal to or over four (4) feet deep and three (3) to one (1) or flatter for channels less than four (4) feet deep.

      c. Curvature. The center line curvature shall have a minimum radius of twice the top width of the 100-year storm flow.

      d. Bottom width. The minimum flat bottom width of all vegetated channels shall be five (5) feet, unless an alternate design is demonstrated by the design engineer to be viable and is approved by the Public Works Director and City Engineer.

      e. Freeboard. All grass-lined channels shall be designed to convey the 100-year storm event. The freeboard for the channel shall be the velocity head for the 100-year storm.

C. Concrete-lined channels. Concrete-lined channels may be needed in channel reaches where the velocities are excessive (See subsection B. 1. of this section) or where the channel characteristics require such use.

   i. Velocity.

      a. In concrete-lined channels the probability of achieving supercritical flow is greatly increased. The designer must take care to ensure against the possibility of unanticipated hydraulic jumps forming in the channel in considering the 10- and 100-year storms. If supercritical flow does occur, then freeboard and superelevation must be determined. In addition, all channels carrying supercritical flow shall be continuously lined with reinforced concrete.

      b. The minimum velocity is two (2) FPS at a two-year storm.

ii. Roughness coefficient. Table 15 provides the Manning's coefficients for concrete-lined channels.

iii. Freeboard. Adequate channel freeboard shall be provided for the 100-year storm in reaches flowing at critical depth by using the energy grade line or the following equation, whichever is less.

$$H_{FB} = 2.0 + 0.025 \times V \times d^{1/3}$$ **Equation 19**

Where:

H_{FB} = Freeboard height, ft

V = Velocity, ft/sec

d = Depth of flow, ft

Note: Freeboard shall be in addition to superelevation, standing waves and/or other water surface disturbances. Concrete sideslopes shall be extended to provide freeboard. Freeboard shall not be obtained by the construction of levees.

iv. Superelevation.

a. Superelevation of the water surface shall be determined at all horizontal curves which deviate more than forty-five (45) degrees off the projected centerline. An approximation of the superelevation at a channel bend can be obtained from the following equation:

$$h = V \times 2 \times \frac{T_W}{g \times r_C}$$ **Equation 20**

Where:

h = Superelevation, ft

V = Flow velocity, ft/sec

T_w = Top width of channel, ft

r_c = Centerline radius of curvature, ft

g = Acceleration due to gravity, ft/sec ^{2}

b. The freeboard shall be measured above the superelevation water surface.

v. Side slopes. Since concrete lined channels do not require slope maintenance, the side slopes may be as steep as vertical with appropriate structural methods applied and included as details in the plans.

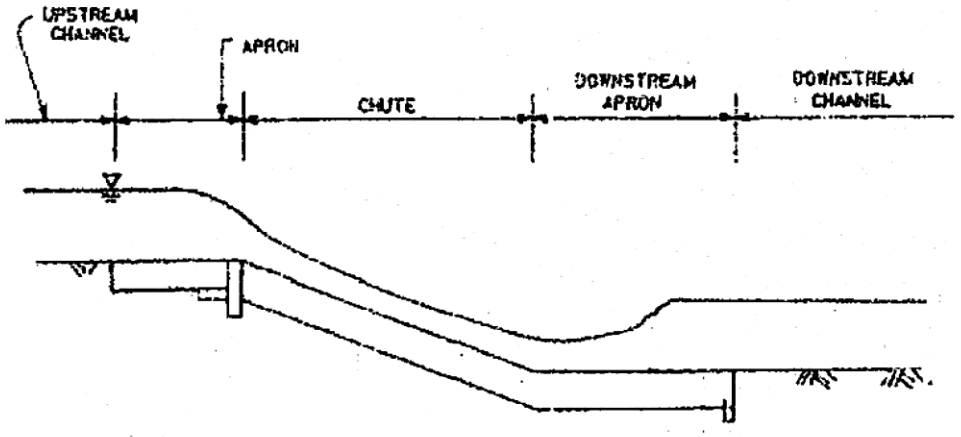
vi. Outfalls. Outfalls shall enter major collector drainage ways and major streams at grade and/or be designed and constructed with adequate concrete aprons, energy dissipators or similar features to prevent erosion.

D. Other channels. Channels composed of materials other than vegetation or concrete shall require written approval by the City Engineer and Public Works Director. Such channels shall be designed so that sediment deposition does not occur for the two-year storm (except for channel drop structures and energy dissipators as approved by the city) and velocities for the 100-year storm are not erosive, using methods as approved by the City Engineer.

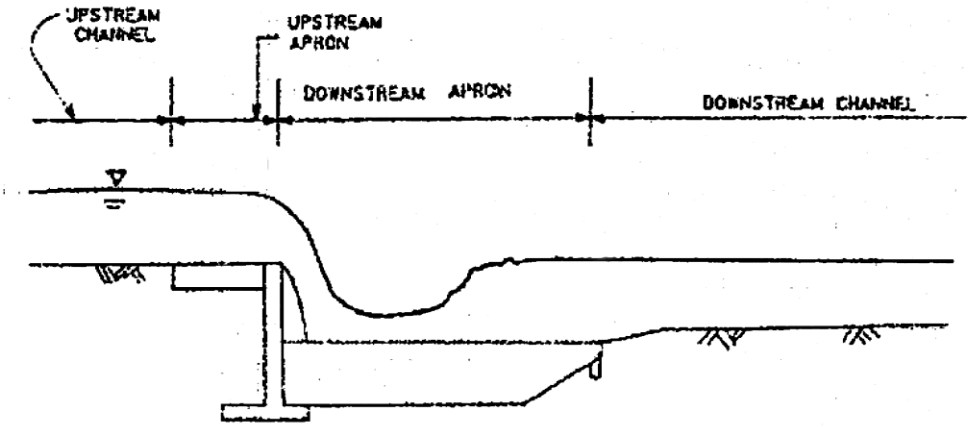
4. Channel Drop Structures.

   A. Channel drop structures.

      i. The function of a drop structure is to reduce channel velocities by allowing for flatter upstream and downstream channel slopes. Two (2) commonly used drop structures are shown in Figure 14.



A. SLOPING CHANNEL DROP



B. VERTICAL CHANNEL DROP

Source: U.S. Bureau of Reclamation, 'Hydraulic Design of Stilling Basins and Energy Dissipators,' Engineering Monograph No. 25, Eighth Printing, Denver, May, 1984.

Figure 14 - Sloping and Vertical Channel Drops

ii. The flow velocities in the upstream and downstream channels of the drop structure need to satisfy the permissible velocities allowed for channels. The design parameters for the sloping channel drop and the vertical channel drop are given below.

B. Sloping channel drop.

i. Approach apron.

a. A minimum ten-foot long riprap apron should be constructed immediately upstream of the drop to protect against the increasing velocities and turbulence which result as the water approaches the sloping portion of the drop structure.

(1) The same riprap and bedding design should be used as specified for the portion of the drop structure immediately downstream of the drop.

ii. Chute.

a. The chute shall have roughened faces and shall be no steeper than two to one (2:1).

b. The length, L, of the chute depends upon the hydraulic characteristics of the channel and drop. L shall not be less than ten (10) feet, even for low flow quantities.

c. Downstream apron.

(1) The length of the downstream apron shall be sized according to Table 18 and shall be constructed of reinforced concrete or riprap depending on structural requirements.

(2) The length of the downstream apron is determined by dividing the maximum design flow rate for the drop structure by the length to determine the maximum unit discharge. The result is compared to Table 18.

Table 16 - Length of Downstream Apron

Maximum Unit Discharge, q (cfs/ft)	Minimum Length of Downstream Apron, L (ft)
0-14	10
15	15
20	20
25	20
30	25

Source: City of Austin, Watershed Engineering Division.

C. Vertical channel drops.

i. The design criteria for the vertical channel drop are based upon the height of the drop and the normal depth and velocity of the approach and exit channels. The channel must be prismatic throughout, from the upstream channel through the drop to the downstream channel.

ii. The steepest allowable sideslope for the riprap stilling basin is four to one (4:1). The riprap should extend up the side slopes to a height equal to one (1) foot above the design water level upstream, downstream, and through the vertical drop. The maximum

fall allowed at any single drop structure is four (4) feet from the upper channel bottom to the lower channel bottom.

a. Approach channel. The upstream and downstream channels will normally be grass-lined trapezoidal channels.

b. Approach apron. A minimum ten-foot long riprap apron is provided upstream of the drop to protect against the increasing velocities and turbulence which result as the water approaches the vertical drop.

c. Chute apron. The riprap stilling basin shall be designed to force the hydraulic jump to occur within the basin and shall be designed for essentially zero (0) scour.

5. Energy Dissipators.

A. General.

i. Energy dissipators are used to dissipate excessive kinetic energy in flowing water that could promote erosion. An effective energy dissipator must be able to retard the flow of fast-moving water without damage to the structure or to the channel below the structure.

ii. Impact-type energy dissipators direct the water into an obstruction that diverts the flow in many directions and in this manner dissipates the energy in the flow. Baffled outlets and baffled aprons are two (2) impact-type energy dissipators.

iii. Other energy dissipators use the hydraulic jump to dissipate the excess head. In this type of structure, water flowing at a higher than critical velocity is forced into a hydraulic jump, and energy is dissipated in the resulting turbulence. Stilling basins are this type of dissipator, where energy is diffused as flow plunges into a pool of water.

iv. Generally, the impact-type of energy dissipator is considered to be more efficient than the hydraulic jump-type. Also, the impact-type energy dissipator results in smaller and more economical structures.

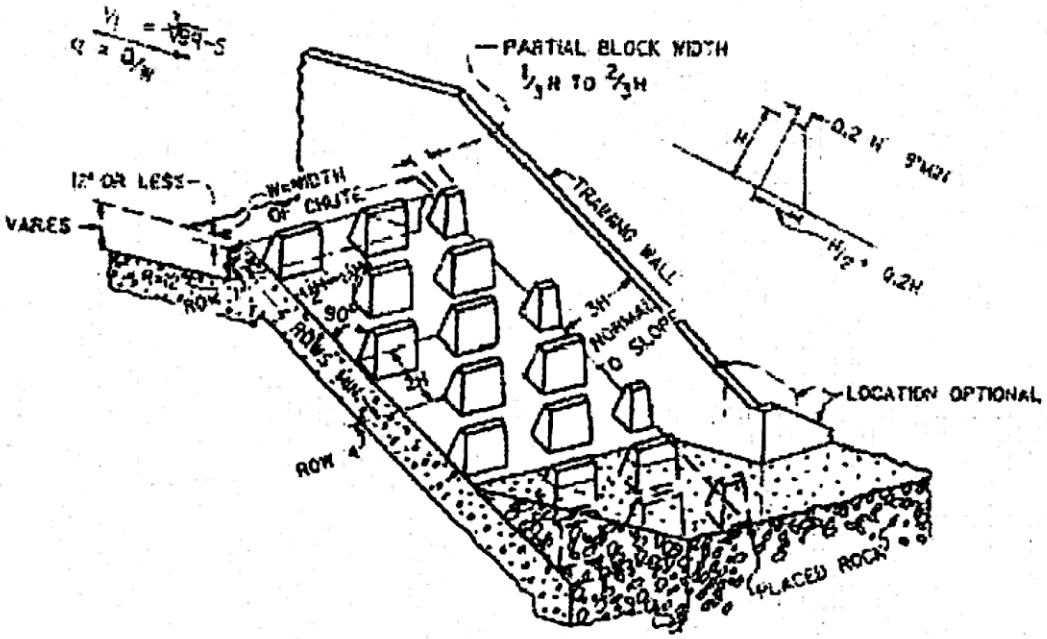
v. The design of energy dissipators is based on the empirical data resulting from a comprehensive series of model structure studies by the U.S. Bureau of Reclamation, as detailed in its book Hydraulic Design of Stilling Basins and Energy Dissipators, 1984. Two (2) impact-type energy dissipators are briefly explained here.

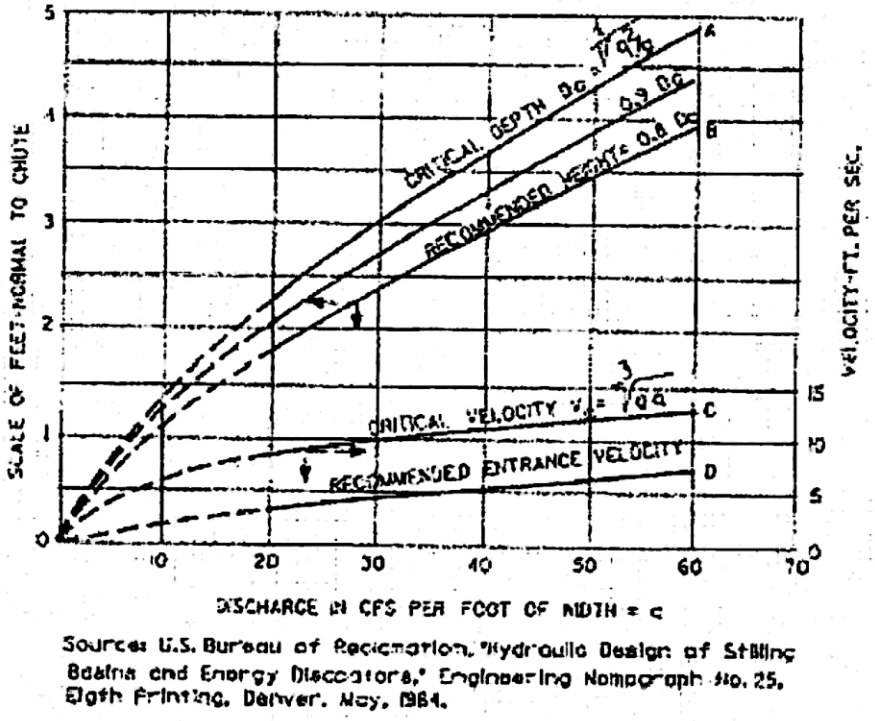
B. Baffled apron (U.S. Bureau of Reclamation Type IX).

i. Baffled aprons are used to dissipate the energy in the flow at a drop. They require no initial tailwater to be effective, although channel bed scour is not as deep and is less extensive when the tailwater forms a pool into which the flow discharges.

ii. The chutes are constructed on a slope that is two (2) to one (1) or flatter and extends below the channel bottom. Backfill is placed over one (1) or more bottom rows of baffles to restore the original streambed elevation. When scour or downstream channel degradation occurs, successive rows of baffle piers are exposed to prevent excessive acceleration of the flow entering the channel. If degradation does not occur, the scour creates a stilling pool at the downstream end of the chute, stabilizing the scour pattern

iii. The simplified hydraulic design of the baffled apron is shown in Figure 15.





Sources: U.S. Bureau of Reclamation, "Hydraulic Design of Stilling Basins and Energy Dissipators," Engineering Monograph No. 25, Eighth Printing, Denver, May, 1984.

Figure 15- Baffled Apron and its Design Curve

iv. The general rules of hydraulic design of a baffled apron are as follows:

a. Design discharge. The chute should be designed for the full capacity expected to be passed through the structure. The maximum unit discharge may be as high as sixty (60) cfs per foot for the 100-year storm.

b. Chute entrance. The flow entering into the chute should be well distributed laterally across the width of the chute. The velocity should be well below the critical velocity, preferably the value shown in the curve D of Figure 15. The curve Figure 15 is the critical velocity in a rectangular channel.

c. Chute design.

(1) The chute is usually constructed on a two (2) to one (1) slope.

(2) The upstream end of the chute floor should be joined to the horizontal floor by a curve to prevent excessive vertical contraction of the flow.

(3) The upstream face of the first row should be no more than one (1) foot (vertically) below the high point of the chute.

(4) Based on the results of U.S. Bureau of Reclamation experiments, the greatest tendency to overtop the training walls occurs in the vicinity of the second and third rows of baffles. To prevent this overtopping, a partial baffle (one-third (⅓) to two-thirds (⅔) of the width of a full baffle) should be placed against the training walls in the first row. This will place a space of the same width adjacent to the walls in the second row. Alternate rows are then made identical (i.e., rows 1, 3, 5, 7, etc., are identical; rows 2, 4, 6, 8, etc., are identical). Four (4) rows of baffles are necessary to establish the expected flow pattern at the base of the chute.

(5) The height of the training walls on the chute should be three (3) or more times the baffle height, measured normal to the chute floor. Several rows of baffle piers are usually constructed below the channel grade to establish full control of the flow. At least one (1) row of baffles should be buried in the backfill which is used to restore the original bottom topography.

d. Heights and spacing of baffle pier.

(1) Baffle pier height, H, should be about eight-tenths (0.8) D_c to nine-tenths (0.9) D_c. D_c is the critical depth in a rectangular channel and determined by:

$$\boldsymbol{D_C = \left(\frac{q^2}{g}\right)^{1/3}}$$

Equation 21

Where:

D_c = critical depth, feet

q = flow rate, cfs

g = acceleration due to gravity, ft/s ^{2}

(2) Baffle pier widths and spaces should be equal, up to 1.5 H but no less than H. The slope distance between rows of baffle piers should be 2H, twice the baffle height.

C. Baffled outlet. Baffled outlets are used to dissipate the discharge energy from flow in a pipe. They are normally used at outlets from detention ponds or storm drainage systems. The baffles are intended to decrease the discharge velocities and subsequent erosion of the receiving system.

6. Structure Aesthetics.

A. Design of hydraulic structures in the urban environment requires an approach not encountered elsewhere because appearance must be an integral part of the design. The treatment of the exterior appearance should not be considered of minor importance.

i. Parks. Hydraulic structures should not detract from the pleasures enjoyed in an urban park. Furthermore, parks and greenbelts may later be developed in an urban area in which the structure will play a dominant environmental role.

ii. Play areas. An important consideration is that drainage structures often are an attraction for neighborhood children. It is almost impossible to make drainage works inaccessible to children, and therefore what is constructed should be made as safe as is reasonably possible. Hazards to children's safety should be avoided whenever possible.

iii. Concrete surface treatment. The use of textured concrete presents a pleasing appearance and removes form marks. Exposed aggregate concrete is also attractive but may require special control of the aggregate used in the concrete.

iv. Rails and fences. The use of rails and fences along concrete walls provides a pleasing topping to an otherwise stark wall, yet provides a safety measure against the hazard of falling from an unprotected wall.

Subsection VII - Natural Streams and Floodplain

1. Natural Stream Requirements

   A. Discharge from storm sewer outfalls shall not cause channel, bluff, or stream bank erosion. If the storm drain discharges to an open drainage facility (as determined by the city), the applicant must show acceptable nonerosive conveyance to that drainage facility, appropriate energy dissipation at the outfall and a stable headwall. No outfalls shall be allowed to discharge on the slope of the receiving channel without proper erosion control protection in the receiving channel.

   B. Section 404 permit. When a project to modify a natural channel is proposed, the design engineer should check the requirements of Section 404, Permits for Dredged or Fill Material, of the Clean Water Act. If required, a permit should be obtained from the U.S. Army Corps of Engineers by the design engineer.

   C. Major streams, defined as streams that are shown on either a USGS quad map or FEMA Flood Insurance Rate Map (FIRM), shall not be modified without consent of applicable state and federal agencies and authorization from the City Engineer

2. Floodplain Management

   A. General.

      i. All development within the floodplain must comply with the requirements of Chapter 4 of the City's Code of Ordinances, specifically the Flood Damage Prevention Ordinance, or latest revision thereof.

      ii. Drainage areas within the subdivision boundary delineated by FEMA on the FIRM as the effective special flood hazard areas for the base flood must be shown on the subdivision plat.

      iii. For the purposes of floodplain management, any concentrated flow within a watershed that has a drainage area of three hundred twenty (320) acres or greater, or any special flood hazard areas defined by FEMA, shall be defined as a floodplain. Floodplains with drainage areas between 320 and 640 acres that are not currently mapped as FEMA effective floodplains will not require a submission to FEMA to define the unmapped regulatory floodplain. Development in any defined floodplain must comply with the requirements of this subsection I.

      iv. All new construction and substantial improvements of buildings (structures) shall have the lowest floor (including basement) the minimum distance above the finished flood elevation as specified in the Flood Damage Prevention Ordinance.

      v. All floodplains shall be computed utilizing the computer software and methodologies accepted by the NFIP.

      vi. If land development activities are proposed which will result in flood hazard boundary delineations different from those depicted on the current FIRM issued by FEMA, the applicant must follow the requirements of the NFIP.

vii. All floodplain delineations for FIRM revisions shall be based upon cross sections created from methodology outlined in the latest revision of FEMA Policy Standards for Flood Risk Analysis and Mapping.

B. Coordination of City of Copperas Cove and FEMA floodplain delineations.

i. General requirements.

a. Any proposed development in the floodplain will require a detailed Hydrologic & Hydraulic study (completed to FEMA standards) that will be presented to the City or City's Consultant for review.

ii. If the floodplain depicted on the FIRM is required to be changed due to updated analysis of the floodplain under existing conditions, then the following requirements are applicable:

a. Prior to approval of a final plat, or if a provisional floodplain developed through an approved H&H study is shown on the plat, then prior to recordation, the applicant must provide to the city evidence of a FEMA approved LOMR/LOMA.

b. Prior to issuance of building permits on lots within the current FEMA FIRM floodplain, the applicant must provide to the city evidence of final acceptance by FEMA of the LOMR/LOMA submitted in accordance with FEMA and City requirements. The requirement for this subsection shall be depicted on the plat as a plat note.

iii. If the floodplain depicted on the FIRM is required to be changed due to land development activities that alter existing conditions, then the following requirements are applicable:

a. Prior to approval of final plat, the applicant must provide to the city evidence of receipt by FEMA of an application for a CLOMR.

b. With prior approval from the City Engineer, the applicant may provide an engineering study, in lieu of a FEMA-approved CLOMR/CLOMA, demonstrating compliance with Copperas Cove Ordinances that is sealed by a Texas Professional Engineer and accepted by the City Engineer. Engineering study must meet the requirements of a CLOMR submission to FEMA. Additional information may be requested from the developer to support submission. Submission of LOMR to FEMA will still be required. In the event that FEMA rejects the LOMR/LOMA, the applicant shall be required to make the revisions FEMA requires to receive LOMR/LOMA approval.

c. Prior to recordation of a final plat, the applicant must provide to the city evidence of approval (either FEMA or City Engineer) of the CLOMR submitted under b. above.

d. If the final plat is approved before it is determined that a CLOMR is necessary or desired, then prior to release of subdivision construction plans, the applicant must provide to the city a letter of acknowledgement by FEMA of receipt of a complete application for a CLOMR or have CLOMR submitted to the City Engineer for review (as outlined in b. above).

e. Prior to issuance of building permits on affected lots, the applicant must provide to the city evidence of final acceptance by FEMA or the City Engineer of the CLOMR and a letter of acknowledgement by FEMA of a complete application for a LOMR. The requirement for this subsection shall be depicted on the plat as a plat note.

f. Prior to issuance of a certificate of occupancy on any development in the floodplain, the applicant must provide to the city evidence of a final acceptance by FEMA of a LOMR/LOMA. The requirement for this subsection shall be depicted on the plat as a plat note.

g. LOMR-F requirements.

(1) The City will allow the submission of a LOMR-F in lieu of a LOMA/LOMR under the following conditions:

(A) The anticipated change in the floodplain delineation will be contained within the developer's property (or contiguous properties) or meets the requirements of Section G.3 below. If the anticipated change in the floodplain on the developer's property is outside of the current FEMA effective floodplain, the area must be encompassed in a drainage easement to prevent future development in the modified floodplain.

(B) No existing structures adversely impacted;

(C) No greater than 1-foot rise in the base flood elevation;

(2) A detailed H&H study may be required to demonstrate compliance with the above requirements. The H&H study must be in a similar format that is acceptable to FEMA.

h. The applicant shall bear the cost of engineering services required to develop the application, respond to review comments, and obtain final approval of LOMRs and CLOMRs. The applicant shall bear the cost of any fees associated with review and disposition of LOMRs and CLOMRs that are established by FEMA.

(1) The fee for City Engineer review of a CLOMR shall match current FEMA fees.

iv. Drainage Easement Requirements for Floodplain Development.

a. Floodplain development that adversely affects area(s) outside of the proposed development, that would not require an easement, would be restricted to each of the following:

(1) No existing structures affected;

(2) Maximum surface area increases of 1% over the existing floodplain on each affected parcel or, if owned by a single landowner, contiguous parcels; and

(3) No increase in flood elevations that exceeds a 1-foot rise.

b. An increase in the floodplain outside of the developed property and in excess of the easement requirements listed above would require a drainage easement. This is based on the following:

(1) Compensation to the current landowner for loss of potential future development of property.

(2) Restricts development in the drainage easement on the affected property.

Subsection VIII - Erosion Control

1. General
    A. Erosion Control must be installed prior to city acceptance and must be maintained until a certificate of occupancy is issued on the property.
    B. Erosion Control Installations shall comply with:
        i. City of Copperas Cove Ordinances, Chapter 11, Article V – Stormwater Management, or latest revision thereof;
        ii. City Standard Details and Specifications, latest version; and
        iii. Current TCEQ requirements, including, if applicable, a Notice of Intent (NOI), Stormwater Pollution Prevention Plan (SWPPP), and any other documentation or submission required for compliance.
    C. Additional measures may be required during and after construction if during subsequent runoff events erosion or sediment damage is documented as a violation of TCEQ regulations or city ordinance by city staff.
2. Design
    A. It shall be the responsibility of the design engineer to provide appropriate best management practices necessary to comply with Federal, State, and City statutes.
    B. Erosion Control Plans and SWPPPs will be prepared by an engineer licensed in the State of Texas.

STREET DESIGN SECTION

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Subsection I - Definitions.

For general definitions, refer to Section 17.5-2 *Definitions,* City of Copperas Cove Code of Ordinances – Subdivisions. For definitions specific to the Street Design Criteria Manual only, see below. In the event of a conflict between the Subdivision Ordinance and this Manual, the definitions in this Manual shall govern.

Arterial streets. The street classification for a primary urban traffic- carrying street or roadway which provides continuity and high traffic volume movement between major centers such as neighborhoods, commercial centers, etc. Arterials are usually spaced at approximately one (1) mile intervals unless terrain or other barriers create a need for major deviation. Required Arterial streets identified in the Transportation Master Plan shall be addressed in a development agreement between the City and the developer and/or property owner.

Collector street. The street classification for a street or roadway which has the primary function to collect and distribute traffic from local streets to arterials streets.

Major Collector. The major collector is applicable to streets that interrupt traffic from residential areas and accommodate this movement to the nearest major collector or arterial and attract low to moderate traffic volumes of five thousand (5,000) to twenty thousand (20,000) vehicles per day.

Minor Collector. The minor collector is applicable to streets that interrupt traffic from residential areas and accommodate this movement to the nearest major collector or arterial and attract low traffic volumes of up to five thousand (5,000) vehicles per day. This type of collector street should be located in a manner to discourage through traffic movements. This type of collector street should be discontinuous near the center of a neighborhood.

Local streets. The street classification for low volume, low-speed streets designed to provide access to abutting residential, commercial, or industrial land.

Major Local – The major local is applicable to residential, commercial and/or industrial areas. This street provides movement from the nearest collector street or higher classification and attract low traffic volumes of up to two thousand (2,000) vehicle trips per day.

Minor Local – The minor Local are streets with low volumes and low speeds designed to provide access to abutting residential land only. Minor local streets shall be streets that meet the following conditions:

A. Originates from a major local street or higher classification on at least one end with a tee intersection;

B. Does not provide sole access to any other street with more than 30 lots.

C. Culs-de-sac and looped (horseshoe) streets may be classified as minor local streets.

Marginal access streets. A street which runs parallel and adjacent to an arterial street and which provides access to abutting properties while protecting them from through traffic.

Vehicle Trips per Day – The number of trips generated by local traffic volume at a specific point. This shall be either 10 vehicle trips per day per dwelling unit or calculated using the latest Institute of Transportation Engineers criteria.

Subsection II - Design Requirements.

1. Alleys. Alleys shall have a minimum right-of-way width of twenty (20) feet and a minimum paving width of eighteen (18) feet edge to edge. Alleys shall be paved and constructed to the City Standard Details and Specifications. All utilities to be located in the alley shall be in place before the alley is paved.

2. Intersections.

   A. Streets shall be designed to intersect as nearly as possible at right angles, and in no case intersect at an angle of less than 75°. An oblique street should be curved approaching an intersection and should be at a right angle to the other street for a least one hundred (100) feet from the intersection. No more than two (2) streets shall intersect at any point unless specifically approved by the City Engineer. Where these conditions are determined to be unavoidable, other design compensations may be required (e. g. setback lines further from the right-of-way than usually required, rounding or cutting of corners, or relocation of an intersection).

   B. Proposed new intersections along an existing street shall, wherever practicable, coincide with existing intersections on the opposite side of the existing street. Any centerline offsets shall be a minimum of 150’ for local streets. Proposed new intersections for local streets shall also meet the 150’ minimum intersection/spacing requirement. No offsets shall be allowed for extension of existing or new arterial streets.

   C. The curb line for urban streets or edge of pavement shall be rounded with a curve of radius R varying with the interior angle of the adjacent lot corner as specified in Table 1. The property line at street intersections shall be rounded with a curve of radius R varying with the interior angle of the adjacent lot corner as specified in Table 2.

   D. Alleys shall be treated as local streets.

3. Driveway Access.

   A. Driveway access to single and two-family lots should be from minor collector or local streets.

   B. Driveway access to single and two-family lots with frontage on more than one (1) street shall be prohibited on the higher street classifications (arterial through major collector) if one (1) frontage of the lot is on a lower street classification (minor collector or local street).

   C. Driveway access to single and two-family lots with frontage on more than one (1) street and all frontages are on a higher street classification, the driveway access shall be from the street with the lowest classification (i.e., from a major collector street rather than from a major arterial street).

D. When driveway access is required from a higher street classification, the driveway shall be constructed so as to provide a paved area for vehicles to turn around on-site and exit the lot without having to be backed into the public right-of-way.

E. A note or a one-foot "no access easement" shall be placed on the plat where driveway access is prohibited.

4. Street Right-of-Way and Paving Width Requirements.

A. The dimensions shown in Table 3 represent minimum requirements for dedicated right-of-way widths or permanent ingress/egress easements and are required of all subdivisions platted within the city and ETJ. These minimums may be increased or decreased by the City Engineer where conditions warrant. Such conditions include but are not limited to intersections which will require turning lanes, where oversize storm drains, water lines, or sewer lines are located adjacent to the street, and unusual topographic conditions.

B. Rural streets shall have roadside drainage ditches with 4H:1V front and back slopes. Rural streets shall require greater right-of-way widths or drainage easements shall be platted on the adjacent lots in order to maintain the required side slopes on the drainage ditches and contain the ditches in the right-of-way or easement. When drainage easements are dedicated in lieu of right-of-way, they shall not be included in any yard setback requirements of the zoning ordinance.

C. Determinations of street classification shall be made by the City Engineer and the City Planner in consultation with the design engineer and shall be based on the needs of the subdivision and the Comprehensive Plan.

D. Additional right-of-way shall be dedicated for subdivisions of two or more lots adjacent to existing boundary streets not meeting the minimum standards of this chapter.

E. For subdivision plats in the ETJ, the developer/owner may subdivide property as required herein by dedicating permanent ingress/egress access easements connecting to a dedicated right-of-way. The dedication shall reflect that the permanent ingress/egress access easement is in lieu of a public dedicated right-of-way. It shall be noted on the plat that no governmental entity shall be responsible to repair, maintain or reconstruct said permanent ingress/egress access easements and that the expenses for the repair, maintenance, or reconstruction of the permanent ingress/egress access easements shall be the responsibility of the homeowner's association (name shown on the plat), organization, or individual homeowner(s). Permanent ingress/egress easements shall be required to meet the minimum requirements for streets in this chapter unless exempted by the City Council.

5. Vertical Curves. Vertical curves shall be designed and constructed to provide the minimum stopping sight distance required in Table 3.

6. Special Purpose Streets.

A. Marginal access streets. A marginal access street may be approved by the city for subdivisions with frontage on an arterial street if it is determined that such a street is needed to provide separation of through and local traffic. If a marginal access street is

provided, it shall be separated from the arterial street by a distance of at least twenty-six (26) feet.

B. Culs-de-sac.

   i. A street terminating in a cul-de-sac shall be no more than six hundred (600) feet in length as measured along the street's centerline from the centerline of the last intersection to the radius point of the cul-de-sac. This minimum may be increased by the City Engineer where conditions warrant.

   ii. The street shall have a minimum right-of-way width and minimum paving width as required for minor residential streets.

   iii. The cul-de-sac (turnaround) shall have a minimum pavement radius of forty-five (45) feet as measured from the center to the back of curb for urban and industrial streets and edge of pavement for rural streets and a minimum right-of-way radius of fifty-four (54) feet as measured from the center to the right-of-way line for urban and industrial streets and sixty-one (61) feet for rural streets.

   iv. The minimum right-of-way radius for rural cul-de-sacs shall be increased or drainage easements shall be platted on the adjacent lots as necessary to accommodate drainage.

C. Dead end or stubbed streets. Dead end or stubbed streets shall be avoided unless future extensions of the street are planned. When a street extension into an undeveloped area is planned, the developer may be required to build the street and construct a temporary turnaround with a paved surface at the end with proper barricading and warning signs or post a security bond for the full cost of future construction of the street plus reasonable inflation. It will be the responsibility of the developer to secure adequate easement or right-of-way for any temporary turnarounds. Dead end or stubbed streets shall not exceed one thousand (1,000) feet in length.

   A paved turnaround may be waived for dead end or stubbed streets which extend only the depth of an average lot and has no more than one (1) lot fronting on each side.

D. Service road. Service roads shall be treated as an arterial for intersection spacing, curb returns, and property line returns.

Table 1 – Minimum Intersection Curb Returns

Interior Angle of Property Lines	Intersection of Local or Collector with Collector or Local Collector	Intersection of Local or Collector with Arterial	Intersection of Arterial with Arterial
105° - 85°	15 ft.	25 ft.	35 ft.
85° - 75°	20 ft.	30 ft.	50 ft.
The pavement return radius for intersections of streets constructed to rural street standards shall be equal to the curb return radius required for the intersection of two arterials.			

Table 2 – Property Line Intersection Returns

Interior Angle of Property Lines	Intersection Type	
	Locals and Collectors	Arterial
105° - 85°	15 ft. Parkway = R	25 ft.
85° - 75°	20 ft. - Parkway = R	40 ft.
The property line return radius for intersections of subdivisions constructed to rural street standards shall be equal to the property line return radius required for the intersection of two arterials.		

Table 3 – Street Design Standards, By Street Classification

Classification	Min. Design Speed	Min. Center Line Radius	Min. Grade [1]	Max. Grade [1]	Stopping Sight Distance	Traffic Lanes	Parking Lanes	Residential Driveway Access	Median	Min. Street Width	Min. Right-of-Way
Major Arterial	This Street Classification is governed by TxDOT. See TxDOT Roadway Design Manual for requirements.										
Minor Arterial	35 mph	700 ft.	0.35%	9.0%	250 ft.	4 @ 12 ft.	None	Restricted	Painted @ 14 ft.	70 ft. back to back	90 ft.
Major Collector	30 mph	375 ft.	0.35%	12.0%	200 ft.	4 @ 11 ft.	None	Restricted	None	48 ft. back to back	70 ft.
Minor Collector	30 mph	300 ft.	0.35%	14.0%	200 ft.	2 @ 11 ft.	2 @ 8 ft.	Permitted	None	41 ft. back to back	60 ft.
Major Local	30 mph	100 ft.[2]	0.35%	14.0%	200 ft.	2@ 11 ft.	2 @ 8 ft.	Permitted	None	35 ft. back to back	54 ft
Minor Local (Urban)	30 mph	100 ft.[2]	0.35%	14.0%	200 ft.	2 @10 ft.	None	Permitted	None	31 ft. back to back	50 ft.
Minor Local (Rural)	30 mph	100 ft. [2]	0.35%	14.0%	200 ft.	2 @ 12 ft.	None	Permitted	None	28 ft. back to back [3]	64 ft.

[1] Can exceed in secondary access ways upon approval of the Public Works Director in consultation with the City Engineer and Fire Chief.

[2] Recommend that as the deflection angle in the street approaches 90°, the design engineer considers reducing the radius to zero (0) to encourage vehicle speed

reduction in the curve. The curb radii will need to meet minimum requirements for intersections (see Table 2). For topographical conditions, the minimum can be modified by the City Engineer, provided that an engineering report that supports the design is submitted by the design engineer.

[3] Street width requirements are a minimum hot mix asphaltic concrete pavement width twenty-four (24) feet edge to edge with either two-foot (2') ribbon curb or four-foot (4') compacted base shoulders on each side of the street. The depth of the compacted base shoulders shall be equal to the depth required for the street.

7. Block size and shape shall be conditioned by the type and use of the proposed development and shall be compatible with the size and shape of blocks in neighboring developments
8. General Requirements for Residential Blocks. Blocks should be at least two hundred (200) feet, but not more than one thousand two hundred (1,200) feet, in length and at least one hundred (100) feet, but not more than three hundred fifty (350) feet, in depth.
    A. Deviation from these general requirements shall be considered on a case by case basis.
    B. The City Planner and the City Engineer shall make a recommendation to the planning and zoning commission and city council.
    C. The length of the block can be increased, provided that the number of lots does not exceed forty (40) for both sides of the street.
9. Appropriate block dimensions in a commercial or industrial development are relative to land use and shall be considered on a case by case basis. Effect on the flow of traffic and safety precautions necessitated by the development shall be primary factors in determining appropriate block length. The City Planner and the City Engineer shall make a recommendation to the planning and zoning commission and city council.
10. Pedestrian Walkways. The city may require the dedication of pedestrian and bicycle access to parks, schools, playgrounds, shopping centers, or other community facilities. The City Planner and the City Engineer shall make a recommendation to the Planning and Zoning Commission and City Council. Where the parks and recreation plan calls for bike trails, a minimum of fifteen (15) feet shall be dedicated. Other pedestrian access easements shall be a minimum of ten (10) feet.
11. Guardrails. Guardrails are to be installed in accordance with the standard details and as and when required by TxDOT standards.
12. Street Pavement Design.
    A. The street pavement design shall be in accordance with the City's standard details and specifications.
    B. The rough cut of the streets can occur without a pavement design, as well as fill for mass grading, as long as it is density-controlled and tested in accordance with City requirements.
    C. The pavement design shall be submitted prior to any base or pavement installation. The anticipated review time is 5 business days.

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General Statements

1. These specifications and associated details were created with the intent of standardizing the infrastructure for the City of Copperas Cove. In the event of a conflict between these specifications and state and/or federal regulations, the state and/or federal regulations shall govern.
2. Please note that the Standard Details are numbered so that they correspond to the primary specification to which they are related.
3. The City of Copperas Cove reserves the right to limit the purchase of specific items and appurtenances to those in these specifications, provided the items conform to the provisions herein. The intent is to reduce the amount of various manufacturers' replacement parts that the City's maintenance department must keep on hand.
4. The "Measurement" and "Payment" sections included in these Standard Specifications are for projects bid out by the City of Copperas Cove, such as Capital Improvement Projects, repair projects, etc. Permanent improvements for developments that will subsequently be accepted by the City do not have to use these sections, but the remaining sections of the specifications still apply.

Specifications 100-199: General

100 – Mobilization

1. Description

This item shall govern the mobilization of personnel, equipment, and supplies at the project site in preparation for beginning work on other contract items. Mobilization shall include, but is not limited to, the movement of equipment, personnel, material, supplies, etc., to the project site and the establishment of office and other facilities necessary prior to beginning the work. Examples of inclusive material are those typical of payment aspects designated as large "EA" items (such as manholes, fire hydrants, water valves, etc.), or "LF" items such as (water or sewer main piping).

2. Measurement

Measurement of the Item, Mobilization, as specified herein, will be by the "Lump Sum," as the work progresses.

3. Payments

Partial payments of the "Lump Sum" bid for mobilization will be as follows: (The adjusted contract amount for construction items, as used below, is defined as the total contract amount, less the lump sum bid for Mobilization and Preparing Right-Of-Way).

a. When 1% of the adjusted contract amount for construction items is earned, 50% of the "Lump Sum" bid or 5% of the total contract, whichever is less, will be paid.
b. When 5% of the adjusted contract amount for construction items is earned, 75% of the "Lump Sum" bid or 10% of the total contract amount, whichever is less, will be deducted from the above amount.
c. When 10% of the adjusted contract amount for construction items is earned, 90% of the "Lump Sum" bid or 15% of the total contract amount, whichever is less, will be paid. Previous payments under this item will be deducted from the above amount.
d. Upon completion of all work under this contract, payment for the remainder of the "Lump Sum" bid for Mobilization will be made.

   NOTES: Cost for Insurance and Bond is inclusive to cost of Mobilization.

e. Payment shall be made by the Inspector for approved materials stored on the project site that are deemed necessary and required for the "PROJECT WORK" in accordance with all contract documents.

110 - Right of Way Preparation

1. Description

This item shall govern preparing the right-of-way for construction operations by removing and disposing of obstructions from the right-of-way and from designated easements where removal of such obstructions is not otherwise provided for in the contract documents.

Such obstructions shall be considered to include: trees and other vegetation, existing fencing, topsoil removal and stockpile, and other debris, as well as the installation and removal of tree protection, where called for in the drawings. This item shall also include obstructions specifically included in the project-specific provisions, specifications, and drawings.

Unless shown otherwise in the contract documents, all fences along the right-of-way which are damaged or removed temporarily by the Contractor shall be replaced by the Contractor to an equal or better condition, at no additional cost to the City.

1. Construction Methods

Areas designated in the contract documents shall be cleared of all obstructions, vegetation, abandoned structures, etc., as defined above, except trees or shrubs specifically designated by the engineer for preservation. Trees and shrubs designated for preservation shall be carefully trimmed as directed and shall be protected from scarring, barking, or other injuries during construction operations. Exposed ends of pruned limbs shall be treated with an approved pruning material.

Unless otherwise indicated in the contract documents, all underground obstructions shall be removed to the following depths:

a. In areas to receive embankment, 2 feet below starting grade.
b. In areas to be excavated, 2 feet below the lowest elevation of the excavation;
c. All other areas, 2 feet below finished grade.

Holes remaining after removal of obstructions shall be backfilled and tamped as directed by the Inspector, and the entire area shall be bladed to prevent ponding of water and to provide drainage. In areas that are to be immediately excavated, backfilling and blading may be eliminated, if approved by the Inspector. Areas to be used as borrow sites and material sources shall have obstructions removed to the complete extent necessary to prevent such objectionable matter from becoming mixed with the material to be used in the construction.

Material to be removed will be designated as “salvageable” or “non-salvageable” in the contract documents prior to bidding by the Contractor. All “salvageable” material will remain the property of the CITY and will be stored at the site as directed by the Inspector. All “non-salvageable” materials and debris removed shall become the property of the Contractor and shall be removed from the site and shall be disposed of properly.

All asphaltic material shall be disposed of or recycled at the facility authorized to accept the asphalt for such purposes and applicable to appropriate guidelines and regulations.

2. Measurement

Preparing Right-of-Way for new construction will be measured by the “Lump Sum.”

3. Payment

This item will be paid for at the contract “Lump Sum” price bid for Preparing Right-of-Way, which price shall be full compensation for work herein specified, including the furnishing of all materials,

equipment, tools, labor, and incidentals necessary to complete the work. 10% of the payment will be withheld until final construction payment.

4. Notes

Additional requirements: Adherence to City Tree Protection Requirements, Section 170.

120 - Trench Excavation & Backfill

1. Description

This item shall govern all excavation, trenching, and backfilling for utility lines and appurtenant structures, which shall conform to the requirements of this specification and to the applicable typical details attached to these specifications. The amount of trench open in advance or left open after pipe laying shall be limited to the length that can be backfilled within the same day.

2. Excavation

Trench excavation shall be to the lines and grades shown on the plans or standard details or as required by the specifications for the line work to be installed therein. The City inspector may direct or authorize deviations where appropriate at his discretion. Excavation for structures shall be sufficient to accommodate forms, where required. Over-depth excavation shall be avoided. All excavation, regardless of the materials encountered, shall be unclassified so far as payment is concerned.

a. Methods of Excavation

Excavation may be performed with any type of trenching or excavating equipment which is capable of cutting properly aligned trenches in whatever materials are encountered. All excavation shall be by open cut unless specifically required to be bored. Blasting will be permitted only when or where specifically approved by the City Manager in writing, and only in the manner specifically approved. Blasting shall conform to all Federal and State laws and Municipal Ordinances. When necessary to prevent caving or unduly hazardous working conditions, trench walls shall be sheathed and braced or shall be laid back from a point six (6) inches above the pipe. If trenching for utilities indicates seepage of ground water into the area under the road bed, subsurface drainage, as approved by the City Engineer, shall be installed.

b. Excavated Materials

All excavated material shall be piled in such a manner that it will not endanger the work in progress and will avoid blocking sidewalks and driveways or obstructing traffic. Driveways must be immediately cleared to permit free access. Gutters and drainage channels shall be kept clear, or other means of securing proper drainage shall be provided.

c. Dewatering

Where ground water is encountered, the water table shall be lowered so that all necessary work may be carried on in the dry. The water shall be kept down until the unit or section under construction is completed. No water shall be allowed to flow through or over unset concrete or through the completed line.

3. Use of Washed Gravel

Where ground water is encountered, four (4) inches of washed gravel will be placed the full width of the trench in lieu of the granular embedment upon which the pipe will rest. The City Engineer will direct the Contractor when and where to place washed gravel.

4. Backfill

Backfill shall be of three types: Granular embedment, Select Backfill, and Trench Backfill

a. Granular Embedment

i. Granular Embedment shall be used under, around, and over all utility lines in accordance with the standard details for utility trenches, except that service lines in soil not containing rock may be installed without embedment.

ii. Granular embedment shall be defined as free-flowing sand or mixed sand and pea gravel that is free of stone, organic material or clay and which material shall not form mud or muck when wet. This material may be an inferior grade or "pit-run" sand not normally considered satisfactory for construction purposes, and it may be used directly from pits without processing.

No fine granular material will be installed by the Contractor without the Engineer's approval.

iii. Granular embedment shall be replaced to a grade slightly higher than required for the grade. Wedging or blocking up of pipe will not be permitted. Each pipe section shall have a uniform bearing on the embedment for the length of the pipe, except for immediately at the joint. Embedment under either water or sewer lines shall amount to at least four (4) inches in earth cut and six (6) inches in rock cut. Granular embedment over the pipe shall be at least twelve (12) inches.

iv. Where sand of a quality meeting the requirements for granular embedment material is encountered in the trench excavation, it may be stockpiled and used in lieu of material from other sources. Compaction of granular embedment by flooding will not be permitted. "Crusherfines" do not constitute approved embedment material.

b. Select Backfill

Select backfill shall:

i. Be used for a depth of twelve (12) inches immediately below the base material of streets or other areas to be paved;

ii. Be of generally granular type material such as base material, road gravel, sand or sandy gravel, and shall have a Plasticity Index less than twenty (20);

iii. Contain no rock larger than three (3) inches in its greatest dimension. Not more than fifty (50) percent of the material shall be rock, and not more than ten (10) percent shall be as large as three (3) inches. Not more than twenty-five (25) percent shall be clay or clay lumps; and

c. Other Trench Backfill

i. In areas outside of streets, drives, and in streets below select backfill material, etc., trench backfill above embedment material may be accomplished by the use of excavated material if the material is suitable for compaction and contains only an occasional rock up to eight (8) inches in greatest dimension.

ii. Trench backfill in areas outside of streets, drives, etc., will not be tested for density, but the material shall be compacted and the entire area left in a neat and orderly condition with excess material mounding over the trench. After a suitable length of time to permit settling, the trench surface shall be brought to a smooth grade.

d. Compaction Requirements

i. Trench backfill shall meet the following compaction requirements

A. Select Backfill shall be compacted to not less than ninety-five (95) percent of Modified Proctor Density, ASTM Designation D1557, in layers of not over six (6) inches in thickness.

B. Backfill in streets above the pipe embedment and below the select backfill shall be compacted to ninety-five (95) percent modified Proctor Density.

e. Compaction Testing

i. Compaction testing is intended to verify that the means and methods employed by the contractor are meeting the requirements of the City.

ii. Compaction testing shall start 2 feet above the top of the pipe and shall continue for every foot of lift every 200 feet of trench length.

A. Once the City Inspector is satisfied with the construction methods and test results, they may reduce the number of tests to a level where the City Inspector is satisfied.

B. 2 subsequent failing tests will result in resetting the test results to the maximum of 1 foot of lift for every 200 feet of trench length until the City Inspector is satisfied with the revised construction means and methods.

5. Existing Structures

At the expense of the Contractor, all existing structures, improvements and utilities shall be adequately protected from damage that may occur due to construction operations. Where construction comes in close proximity to existing structures or utilities, or if it becomes necessary to move services, poles, guy wires, pipelines, or other obstructions, the Contractor shall notify and cooperate with the utility or structure owner.

6. Payment

Payment for this item shall be subsidiary to the item to which it relates. Payment shall include all labor, material, equipment to accomplish this item.

121 - Trench Safety Systems

1. **Description**
   This item shall govern for the Trench Safety Systems required for all trench excavation and including all additional excavation and backfill necessitated by the safety system. A trench shall be defined as a narrow excavation (in relation to its length) made below the surface of the ground. Trench Safety Systems include, but are not limited to, sloping, sheeting, trench boxes or trench shields, sheet piling, cribbing, bracing, shoring, dewatering or diversion of water to provide adequate drainage.

2. **Construction Methods**
   Trench safety systems shall be accomplished in accordance with the detailed specifications set out in the provisions of Excavations, Trenching, and Shoring, Federal Occupational Safety and Health Administration (OSHA) Standards, 29CFR, Part 1926, Subpart P, as amended, including Proposed Rule published in the Federal Register (59 FR 40730) on August 9, 1994. The sections that are incorporated into these specifications by reference include Sections 1926-650 through 1926-652. Legislation that has been enacted by the Texas Legislature (H.B. No. 662, H.B. 665 and Texas Health and Safety Code, Title 9, Ch. 756, Sub. C. Trench Safety) with regard to Trench Safety Systems, is hereby incorporated, by reference, into these specifications.

   If the Contractor elects to use a trench protective system that, in the Proposed Rules, requires “design by a registered professional engineer” (1926-652(b)(4) and 1926-652(c)(4)), the “registered professional engineer” shall be a Professional Engineer Registered in the State of Texas.

3. **Safety Program**
   The Contractor shall submit a safety program and trench design specifically for the construction of trench excavation. Trench design shall be signed by a Professional Engineer licensed in the State of Texas.

   The trench safety program shall be in accordance with OSHA standards governing the presence and activities of individuals working in and around trench excavation.

4. **Inspection**
   The Contractor shall make daily inspections of the Trench Safety Systems to ensure that the systems meet OSHA requirements. Daily inspection is to be made by a competent person provided by the Contractor with actual experience in trench safety systems.

   If evidence of possible cave-ins, or slides, is apparent, all work in the trench shall cease until the necessary precautions have been taken by the Contractor to safeguard personnel entering the trench. It is the sole duty, responsibility and prerogative of the Contractor, not the Owner or the Engineer, to determine the specific applicability of the designed trench safety systems to each field condition encountered on the project. The Contractor shall maintain a permanent record of daily inspections.

5. **Measurement**
   This item shall be measured by the “Lump Sum”.

6. **Payment**
   This item will be paid for at the contract “Lump Sum” price bid for Trench Safety Systems, which price shall be full compensation for work herein specified, including the furnishing of all materials, equipment, tools, labor, and incidentals necessary to complete the work. 10% of the payment will be withheld until final construction payment.

122 - Pavement Restoration

1. **Description**
   This item shall govern the restoration of pavement after the construction of a utility within a roadway.

2. **Materials**
   Materials for pavement restoration shall be in accordance with Section 500 – Streets, Walks, and Driveways, of these specifications.

3. **Construction**
   Existing pavement shall be precut, sawed or scored so as to result in an even, straight cut. After completion of the trench backfill, and upon approval of the Engineer, on all paved streets other than gravel streets, the Contractor shall cut and excavate the surface and base of the streets back on each side of the trench to form a shoulder for the new base and surfacing for a minimum of 12” on each side of the trench wall. The base, if stone, shall then be replaced in three (3) inch layers tamped in place. On gravel streets, six (6) inches of road gravel shall be rolled in place to serve as a wearing surface. All cutbacks shall be to a neat, straight line, and the paving cut shall be made with a concrete saw and shall be parallel to the center line of the pipe. Where excess surfacing has been removed beyond the nominal limits of the ditch, such areas shall be kept to a minimum, and where excess of such areas shall be cut parallel to the pipe. All stone or gravel base or surface course shall be compacted to ninety-five (95) percent Modified Proctor Density, ASTM Designation D1557.

   In all paved streets the trench shall be finished in a workmanlike manner with the same type of roadway which was removed so that the underlying courses, as well as the wearing surface, shall conform to the remainder of the roadway and shall be equal in every respect to the improvements existing prior to excavation. Asphalt shall be installed such that after rolling and compaction the restored area will be level with the existing surface.

4. **Measurement**
   Street restoration shall be measured by the square foot of surface replaced.

5. **Payment**
   Payment for Pavement Restoration shall be paid for at the contract unit price bid for each square foot of surface replaced. Payment shall include all equipment, labor, material, tools, and incidentals necessary for the complete replacement as called for in the plans and details.

130 - Encasement Pipes, Jacking & Boring

1. Description

This item shall govern the installation of water or sanitary sewer lines through a casing piping using boring and/or jacking technologies to avoid disturbance to surface features.

2. Submittals

Contractor shall submit manufacturer's product data, instructions, and recommendations.

3. Materials

a. Encasement Pipe

All carrier pipes installed by boring or jacking shall be placed in an encasement pipe.

The minimum nominal size of the casing shall be large enough to accommodate the outside diameter of the bells of the carrier (main) pipe plus two (2) inches, unless otherwise required by the railroad and/or TxDOT. All casing pipes exposed to the atmosphere must be painted per the standard specifications.

Casing shall be steel with a minimum thickness of:

i. 1/4-inch for casings up to and including 18-inch nominal diameter
ii. 3/8-inch for casings greater than 18-inch and up to and including 24-inch nominal diameter
iii. 1/2-inch for casings greater than 24-inch and up to and including 42-inch nominal diameter.
iv. Larger casings shall have their thickness determined by the engineer of record.

b. Joints

All joints for the carrier pipe shall be mechanically restrained within the limits of the encasement pipe. This includes pressure and gravity pipelines.

c. Spacers

Casing spacers shall be provided for all boring/jacking operations. The casing spacers shall have stainless steel bands and fasteners with reinforced plastic runners. The size, length, number, and location of the spacers shall be per the manufacturer's recommendation. Approved spacing manufacturers are Phoenix (Cascade Manufacturing Co.), Advanced Products and Systems, Inc., or pre-approved equal. All metal hardware shall be stainless steel, acceptable for use in sewage environments.

d. Annular Space

The annular spaces on the outside of the encasement pipe shall be filled by pressure grouting for the entire length before the carrier pipe is set in place.

e. Encasement Ends

The ends of the encasement pipe will be sealed with a boot or seal wrap to prevent migration of adjacent backfill into the encasement pipe. End seals shall be made from 1/8" thick neoprene rubber, Advanced Products and Systems, Inc. Model AWN, or pre-approved equal.

Waterline bores under State highways or large creeks/rivers (generally defined as bores in excess of 100 feet) shall have isolation valves provided on both sides of the bore.

4. Construction

a. Jacking

Suitable pits or trenches shall be excavated for the purpose of boring and jacking. Such pits and trenches shall be securely sheeted and braced in accordance with all laws and regulations. Boring and jacking operations shall not interfere with the operations of railroads, streets, highways, or other facilities.

The casing to be jacked shall be set on guides for support and to direct the casing in the appropriate line and grade. Material shall be excavated just ahead of the casing and the material removed through the pipe. The casing shall be forced through the opening created in this manner.

Generally, the line shall be jacked from the downstream end. Permissible lateral or vertical variation in the position of the pipe from line and grade will be as determined by the Engineer.

Any pipe that is damaged in jacking operations shall be removed and replaced at the Contractor's expense. Jacking pits/trenches shall be backfilled immediately upon completion of jacking operations. Jacking pits/trenches in streets shall be backfilled with twelve (12) inches of flowable fill or cement-stabilized backfill immediately below the subgrade.

b. Boring

Boring operations may include a pilot hole which shall be bored the length of the crossing and used as a guide for the larger hole to be bored. Water or drilling fluid may be used to lubricate cuttings, and shall be disposed of in an appropriate manner. Variation in line and grade shall apply as specified under "Jacking".

c. Joints

The casing shall be supported using the spacers at distances as recommended by the manufacturer. The joints for water pipe shall be restrained in accordance with manufacturer recommendations and using restraints appropriate to the pressure requirements.

5. Measurement

This item shall be measured by the linear foot of boring or tunnel as measured from face to face of the jacking pits.

6. Payment

The work performed and materials furnished as specified, shall be paid for at the contract unit price bid per linear foot of jacking, and tunneling. Such price shall include the boring, casing, carrier pipe, casing spacers, end seals, grout, labor, tools, equipment, and incidentals necessary to complete the work, including excavation, backfill, grouting, restoration to original ground conditions, and disposal of surplus materials necessary to install a complete casing with the carrier pipe inserted to the grade, alignment, and length as specified on the plans.

140 - Fencing

1. Description

This item shall govern furnishing and installing fencing and gates at locations shown on the Drawings or directed by the Engineer or designated representative, including all posts, bracing and accessories as specified in this Item and as indicated on the Drawings. Reference to TxDOT requirements.

2. Materials

a. Chain Link Fencing

Chain link fencing shall conform to the requirements of TxDOT Item 550 – Chain Link Fence.

b. Woven Wire Fencing

Woven wire fencing shall be either galvanized steel wire fencing or aluminum-coated steel wire fencing conforming to the following requirements:

i. Galvanized steel wire fencing shall conform to ASTM A116, Class 1.
ii. Aluminum-coated steel wire fencing shall consist of aluminum-coated steel wire conforming to the requirement for galvanized steel wire fencing, except the wire shall be aluminum coated. The wire shall not have less than 0.40-ounce coating of aluminum alloy per square foot of uncoated surface in accordance with ASTM A491

c. Wire Fencing

Wire fencing shall conform to the requirements of TxDOT Item 552 – Wire Fence.

d. Wood Fencing

Wood for wood fencing shall be Wolmanized pine, cedar or as indicated on the Drawings. The timber shall be sound and free from all decay, shakes, splits or any other defects, which would make it structurally unsuitable for the intended purpose.

e. Mowing Strip

When called out in the drawings, a mowing strip shall be Class A concrete. It shall be 24 inches wide and a minimum of four (4) inches thick. Three number three (#3) bars shall be evenly spaced and supported along the full length of the mow strip, and a number three (#3) bar shall be cross-tied every four (4) feet. Fence posts shall be installed in center of mow strip.

3. Construction Methods

a. Chain Link Fence

The Chain Link Fence shall be erected to lines and grades established by the Engineer or designated representative in accordance with the details indicated on the Drawings. The fence shall be true to line, taut and shall comply with the best practice for fence construction of this type.

Construction of the chain link fence shall also be governed by TxDOT Item 550 – Chain Link Fence.

b. Wire Fencing

Wire fencing shall be governed by TxDOT Item 552 – Wire Fence.

c. Wood Fencing Material

After all posts have been permanently positioned and anchorages firmly set, stringers shall be placed and boards secured to the stringers. Other techniques utilizing modular precut panels may be used, when indicated on the Drawings.

4. Removal and Relocation of Existing Fences

This item shall govern the removal and relocation of existing fence, gates and hardware to a new alignment at the location in conformance to the typical details indicated on the Drawings or as directed by the Engineer or designated representative.

a. Removal of Existing Material

The existing boards, fabric, posts, wire, rails, braces, hardware, gates and miscellaneous items shall be carefully removed, bundled, rolled and stockpiled as indicated on the Drawings for installation at the new fence assignment. The removal and handling shall be such that the fence materials may be reused in the relocated fence, if indicated by the project drawings, provisions, and/or specifications.

b. Removal of Fabric and Wire

Fabric and wire of all types shall be carefully untied or disassembled from the posts and other appurtenances and shall be rolled in bundles of a size that will allow handling with ordinary equipment.

c. Removal of Posts

Posts shall be carefully removed from the ground and the concrete footing removed. The concrete shall be disposed of off-site. Post holes shall be filled with suitable embankment material and thoroughly compacted.

d. Removal of Boards

Boards of all types shall be carefully disassembled from the rails and other appurtenances to facilitate removal in panels. Excess material removed shall be disposed of as indicated below.

e. Storage of Materials

Storage of all salvageable materials that will be reinstalled at a new location shall be stored on-site or at such other locations as the Contractor may elect, subject to approval by the Engineer or designated representative. Security and maintenance of the salvageable materials shall be the responsibility of the Contractor.

f. Excess Materials

Materials, that are damaged, unsuitable for reinstallation or unnecessary for completion of the scope of the fence work in the new alignment shall be considered as excess but shall be offered to the Owner before removal from the site by the Contractor.

5. New Materials

New materials that are required to complete the fence at the location indicated on the Drawings shall be of equal quality to the existing materials. Used materials from other projects or from the Contractor's own used material stocks will not be allowed. The new materials to be furnished will be those necessary to replace items from the existing fence which were damaged during removal operations or which for other reasons cannot be reused.

6. Construction Methods

The removed fence shall be installed at the new assignment in accordance with the typical details indicated on the Drawings and shall comply with these specifications and the best practices for fence construction of the specified type.

7. Fencing for Excavations

This item to consist of temporary safety fencing supported on posts and constructed of materials as indicated and removed when excavation is backfilled.

a. Materials

i. Fabric to be four (4) feet in width, made of high-density polyethylene resin, extruded and stretched to provide a highly visible international orange, non-fading fence which will remain flexible from -60 F to 200 F, and be inert to most chemicals and acid. Pattern may vary from diamond to circular with a minimum weight per foot of 0.4 lbs./Ft., a 4-foot width minimum tensile yield strength (horizontal) of 2000 psi, ultimate tensile strength of 2680 psi (horizontal) and a maximum opening no greater than 2 inches.

ii. Posts

Steel pipe, tee posts, U posts or 2" x 4” timber posts, 5½ feet in length minimum, spaced no more than 8 feet on centers. Fabric to be secured to post by bands or wire ties.

8. Construction Methods

Prior to commencing construction suitable "Barricades, signs and traffic handling" devices to be installed to protect workers and public. Safety fencing to be erected to lines and grades indicated. Excavations within 750 ft. of schools or day care centers require special attention by Contractor to secure entry while work is in progress. Fence to be installed prior to excavation and maintained until excavation is backfilled. Fence to be placed a minimum of 4 feet from edge of excavation. Posts to be driven in ground a minimum of 18 inches. At completion of each day's work, safety fencing to be pulled taut, and entry secured. When safety fence is no longer needed, Contractor to remove fence and posts and patch any damage to surfaces.

9. Measurement

All fence-related items shall be measured by the linear foot, except for gates, which will be measured by each gate.

10. Payment

The work performed and materials furnished as specified, shall be paid for at the contract unit price bid per linear foot of fencing. Gates shall be paid for at the contract unit price per each gate. Such price shall include all labor, tools, equipment, and incidentals necessary to complete the work as specified on the plans.

150 - Soil Decompaction

This item shall govern the materials and construction methods for decompacting soil to allow for water infiltration for root growth and drainage of storm water.

1. Definitions

a. Air tillage, fertilizer, mulch (AFM): is a soil decompaction and amendment process for trees involving decompaction with a pneumatic air tool while simultaneously incorporating organic matter and fertilizer into the soil.

b. **Critical Root Zone:** also called the root protection zone. This zone is defined as an area on the ground, generally circular, corresponding to the dripline of the tree.

c. Compacted soil: High density soil lacking structure and porosity and characterized by restricted water infiltration and percolation (drainage), and limited root penetration.

d. Permanent Wilting Point: Water content of a soil when most plants growing in that soil wilt and fail to recover their turgor upon rewetting.

Table 150.1

Soil type	Permanent wilt point v/v	Field capacity v/v
Sand, Loamy sand, Sandy loam	5 - 8%	12 - 18%
Loam, Sandy clay, Sandy clay loam	14 - 25%	27 - 36%
Clay loam, Silt loam	11 - 22%	31 - 36%
Silty clay, Silty clay loam	22 - 27%	38 - 41%

Source: 015639 Tree and Plant Protection Specification (www.isa-arbor.com)

e. **Planting Soil:** Approved topsoil and topsoil mix in accordance with ASTM D5268 “Standard Specification for Topsoil Used for Landscaping Purposes.”

f. **Scarify:** Loosening and roughening the surface of soil and sub soil prior to adding additional soil on top.

g. **Soil Ripping:** Loosening the soil by dragging a ripping shank or chisel through the soil to the depths and spacing specified.

h. **Soil Tilling:** Loosening the surface of the soil to the depths specified with a rotary tine tilling machine, roto tiller, or spade tiller.

i. **Surface Soil Compaction:** A maximum of six (6) inches deep and the result of traffic, light grading, or other impacts.

j. **Subsoil or Deep Soil Compaction:** Deeper than six (6) inches, and may be the result of previous grading, filling and dynamic or static compaction forces.

k. **Topsoil:** Naturally produced and harvested soil from the upper layers of the soil.

l. **Vertical Mulching:** A soil decompaction method for tree root zones involving drilling or air spading a series of shallow holes in the root zone and filling them with compost or other materials.

2. Materials

The Contractor shall be responsible for supplying all supplies and equipment in sufficient quantities so as to perform soil decompaction as necessary without delaying construction progress.

a. **Compost:** Blended and ground leaf, wood and other plant-based material, composted for a minimum of nine (9) months and at temperatures sufficient to break down all woody fibers, seeds and leaf structures, free of toxic material at levels that are harmful to plants or humans.

Source material shall be yard waste trimmings blended with other plants or other materials designed to produce compost high in fungal material. Non-vegetal source materials may be acceptable upon approval by the Owner. The compost will possess no objectionable odors and shall not resemble the raw material from which it was derived.

i. Compost shall be commercially prepared compost and meet US Compost Council STA/TMECC criteria or as modified in this section for "Compost as a Landscape Backfill Mix Component".

http://compostingcouncil.org/admin/wp-content/plugins/wp-pdfupload/pdf/191/LandscapeArch_Specs.pdf

b. **Mulch (hardwood):** Mulch shall be coarse-ground and derived from hardwood (e.g., oak, elm) trees and woody brush sources. No more that 25% of the total volume shall be fine particles and no more than 20% of total volume shall be large pieces, where fine particles are defined as less than 3/8 inch in size and large pieces are defined as either larger than 1½ inch in diameter or longer than eight (8) inches. The mulch shall be free from foreign materials.

3. Construction Methods

a. **General.** Before initiation of decompaction activities, all required erosion control and environmental measures shall be in place as indicated on the drawings, and the depth(s) and location(s) of underground utilities shall be verified. The surface of the subgrade shall be shaped in general conformity with the typical sections, lines, and grades indicated on the drawings by the removal of existing material or by the addition of approved material as established by the Engineer.

This specification covers decompaction of (1) surface soils (0 - 6 inches) and/or (2) subsoil (below 7 inches) as show on the drawings. Requirements for decompaction of soils within the critical root zones of existing trees are also described.

i. The following are general threshold levels of compaction as determined by three compaction testing methods, including the bulk density method, standard proctor method, and penetration resistance method.

A. Compaction levels that are detrimental to root growth are dependent on soil type, which typically varies from site to site.

B. Excellent to Good Compaction: Good rooting anticipated, but increasing settlement expected as compaction is reduced and/or in soil with a high organic matter content.

C. Fair Compaction: Root growth is limited with fewer, shorter and slower growing roots.

D. Poor Compaction: Roots not likely to grow but may penetrate soil when soil is above field capacity.

Table 150.2 Comparison of Compaction limits by various methods

COMPACTION RATING	BULK DENSITY (g/cm^3)	STANDARD PROCTOR (%)	PENETRATION RESISTANCE (PSI) [1]
Excellent	<1.10 to	75 - 85%	75 - 125 [2]
Good	<1.60		126 - 175
Fair	1.39 to 1.69	>85%	176 - 225
Poor	>1.47 to >1.80		>225

[1] Acceptable test methods include ASTM D3441 Standard Test Method for Mechanical Cone Penetration or methods described in references such as Methods for Soil Analysis, Part 1,

Physical and Mineralogical Methods, 2nd ed., EA Klute, ed. (Soil Science Society of America: Madison, WI 1986).

[2] Penetration resistance method: Below 75 psi soil becomes increasingly unstable and will settle excessively.

ii. All soil management activities including amendment and/or decompaction must occur at a soil moisture content between 5 - 20% measured at the depth of the work.

iii. Compacted Surface Soil (0 - 6 inches): Tilling. Surface tilling shall not be considered adequate to reduce compaction at depths seven (7) inches or greater below finished grade.

A. After rough grading and removing all plants and debris from the surface, till top six (6) inches with a roto tiller, spade tiller, or other equipment approved by the Engineer. Spread three (3) inches of compost on the surface of the tilled soil.

B. Till the compost into the loosened soil. Smooth out grades with a drag rake or drag slip. An even bed, with limited irregularities, lumps or soil clods shall be prepared. Clods or rocks larger than two (2) inches shall be removed.

iv. Compacted Subsoil (7 - 24 inches): Soil Ripping

A. After rough grading and removing all plants and debris from the surface, loosen the soil by dragging a ripping shank or chisel through the soil to depths of twenty-four (24) inches maximum. Shank spacing shall be as specified by the Engineer.

B. At least three (3) separate series or patterns of movement are required.

1). The first series or pattern of passes is applied lengthwise, parallel with the longest spread of the site; gradually progressing across the site's width, with each successive pass.

2). The second series runs obliquely, crossing the first series at an angle of about 45 degrees.

3). The third series runs at right angle or 90 degrees to the first series.

C. Spread three (3) inches of compost or other specified amendment over the ripped area and till the material into the top six (6) inches of the soil surface using a roto-tiller or other approved method. An even bed, with limited irregularities, lumps or soil clods shall be prepared. Clods or rocks larger than 2" shall be removed.

v. Compacted Subsoil (7 - 24 inches): Subsoiling

A. Drag a ripping shank or chisel thru the soil to depths of twenty-four (24) inches maximum. Shank spacing shall be as specified by the Engineer. Do not disturb soil or plants in the areas between subsoiled trenches.

B. Fill subsoiled trenches with compost to create a uniform surface grade

vi. Compacted Soil within the critical root zone of existing established trees: Full AFM or Vertical Mulching.

Two techniques are described based on tree location relative to the floodplain and potential for adverse erosion.

Under no circumstances should decompaction work be done in the critical root zone, unless indicated on the plans.

A. Remove the tops of all plants to be removed from the root zone. Remove sod with a walk behind sod cutter. Do not grub out the roots of plants to be removed.

B. Prior to beginning work, the proposed area shall be sufficiently wetted twenty-four (24) hours in advance to minimize dust to the greatest extent possible.

C. Use a pneumatic air tool such as an air knife or air spade.

D. Method 1 - Full AFM: In a location outside the floodplain and on slopes of 3:1 or less, use a pneumatic air tool to loosen the top nine (9) to twelve (12) inches of the soil in the entire dripline. In cases where nine (9) to twelve (12) inches is not attainable (i.e., shallow soil), apply aeration to the depth of soil present. Surface roots may move and separate from soil during this process but the bark on roots should not be broken. Make chemical adjustment as recommended by the soil test. Add three (3) inches of compost over the soil immediately after aeration. Use a pneumatic air tool to mix the compost into the top six (6) to eight (8) inches of the loosened soil. Apply a minimum of three (3) inches of shredded hardwood mulch across the entire treatment area, but kept back one (1) foot from the trunk.

E. Method 2 - Vertical Mulching: This technique is suitable for a floodplain or other location subject to adverse erosion. Use a pneumatic air tool to make one (1) inch minimum diameter holes to a depth of ten (10) to twelve (12) inches with holes three (3) feet on center from the half critical root zone (CRZ) to the dripline. Funnel compost into the holes. Apply three (3) inches of shredded hardwood mulch across the entire treatment area, but kept back one (1) foot from the trunk.

F. Work in sections such that the entire process - including any proposed irrigation - can be completed in one day for each section. Apply ten (10) gallons of water per inch in diameter of DBH over the loosened soil at the completion of each day's work except during precipitation events of half inch or greater. During drought or other prolonged dry periods, continue to provide supplemental water for one (1) to three (3) weeks minimum after treatment.

vii. Protection of Decompacted Soils: After any decompaction activities have taken place do not pass motorized equipment or stockpile construction materials or equipment on previously decompacted soil.

The Contractor shall protect decompacted soil from damage including contamination and re-compaction due to other soil installation, planting operations, and operations by other Contractors. Maintain protection of decompacted areas until project acceptance. Utilize fencing and matting as required or directed to protect the finished soil work. Treat, repair or replace damaged decompacted soil immediately.

viii. Repair of Re-compacted Soils: After decompaction has taken place, any soil that becomes re-compacted to a density greater than 225 psi shall be decompacted again.

A. Loosen compacted soil and replace soil that has become contaminated as determined by the Engineer. Re-compacted and/or contaminated soil shall be loosened or replaced at no expense to the Owner.

B. Where modified existing soil has become compacted or contaminated and needs to be replaced, provide imported soil that is of similar composition, depth and density as the soil that was removed.

4. Payment

Payment for this item shall be subsidiary to the Right-of-Way Preparation item.

160 - Tree Protection

1. Description

This item shall govern the proper care, protection and treatment of trees and other vegetation in the vicinity of the proposed construction. Tree Protection shall be provided where indicated on the drawings.

2. Materials

a. Protective Fencing

Protective fencing is designated as the materials used to protect the root zones of trees as illustrated in the Standard Details.

i. High visibility plastic construction/safety fencing.

The fabric shall be 4 feet in width and made of high density polyethylene resin, extruded and stretched to provide a highly visible international orange, non-fading fence. The fabric shall remain flexible from -60°F to 200°F and shall be inert to most chemicals and acid. The fabric pattern may vary from diamond to circular with a minimum unit weight of 0.4 lbs./foot.

The fabric shall have a 4-foot width minimum tensile yield strength (Horizontal) of 2000 psi, ultimate tensile strength of 2680 psi (Horizontal) and a maximum opening no greater than 2 inches.

ii. T-posts.

iii. The fencing materials, shall be supported T-posts that are a minimum of 5½ feet in height and spaced no more than 10 feet on centers. The fabric shall be secured to post by bands or wire ties.

b. Trunk Protection Recommendation

When trees are near a roadway or construction area, tree trunk protection is recommended and shall consist of any 2 x 4-inch or 2 x 6-inch planking or plastic strapping that is attached in a manner that does not damage the tree.

c. Fertilizer

Humate/nutrient solutions with mycorrhizae components or soil injection at recommended rates are to be used when appropriate. Construction which will be completed in less than 90 days may use materials at half the recommended rates. Alternative organic fertilizer materials are acceptable when approved by the City of Copperas Cove.

3. Construction Methods

a. Protective Fencing

All individual or groups of trees, shrubs, and natural areas shown to be protected on the drawings or identified to be protected by the City of Copperas Cove, shall be protected during construction with temporary fencing as indicated on the drawings.

Protective fences shall be installed prior to the start of any site preparation work (clearing, grubbing, or grading), and shall be maintained in functioning condition throughout all phases of the construction project.

b. Pruning and Repair of Damage

A minimum clearance height of eight (8) feet above the street level should be provided and maintained for all existing trees if adjacent to a sidewalk. However, if the limbs of trees overhang the curb line or edge of travel lane of any street, a minimum clearance height of fourteen (14) feet is required.

c. Tree Removal

All trees to be removed shall be performed in a manner that does not damage the canopies, trunks or root systems of remaining trees and that protects all existing facilities, improvements and vegetation. All tree material shall be removed from the site or used as wood chips or mulch.

When a tree or shrub is scheduled for removal, it shall be cut to a maximum depth of 12 inches below the surrounding grade (the tree(s) should be removed at grade, and with hand saws, in situations where other tree root systems are present which are to be preserved). When applicable, after tree removal, soil shall be placed in the hole to a depth matching the existing grade.

d. Final Cleanup

All temporary tree and shrub preservation and protection measures shall be removed when the construction has been completed and any mulch applications shall be removed or reduced to no more than 3 inches depth.

e. Oak Wilt Prevention Policy

i. Purpose and Scope

The purpose of this Oak Wilt Prevention Policy is to identify measures that city staff and city-hired contractors and their sub-contractors, who perform the services of removing or trimming trees, will take to prevent the spread of oak wilt.

ii. Definitions

Oak Wilt Disease: A tree disease caused by the fungus, Ceratocystis fagacearum. The fungus infects the vascular system of a tree. The vascular system contains vessels which transport moisture throughout the tree. The vessels of an infected tree effectively become blocked by the infection of the fungus, and cannot transport adequate moisture to sustain a healthy or living tree. In most cases, the end result is tree mortality.

iii. Prevention Policy

A. Prior to beginning field work, all city staff associated with projects involving potential contact with oak trees shall be made aware of the city's official Oak Wilt Policy by receiving and reading a written copy of this policy. Staff receiving a written copy of the policy shall include, but not limited to, project managers, equipment operators responsible for removing or trimming trees, or operators using heavy equipment which could cause wounding of susceptible oaks in the use of the equipment. In addition, individual city departments will provide a written copy of the Oak Wilt Policy to contractors participating in city projects in areas where oak trees are present before initiating field work.

B. When possible, city staff and contractors should avoid trimming, pruning, or wounding Live Oaks and Red Oaks (Spanish, Shumard, Texas Red, and Blackjack oaks) from February through June.

C. At all times and irrespective of limb size, all cuts and wounds to oak trees shall be dressed immediately using a non-phytotoxic tree wound dressing. Stump cuts and damaged roots (both above and below ground) shall also be dressed.

D. Disinfection of pruning tools, saws, and related equipment is mandatory during the trimming or pruning of oak trees. Disinfection of tree removal and trimming equipment shall occur before work begins in a project area, between work in individual oak trees, and again prior to leaving a project area. Acceptable disinfectants include either aerosol disinfectant or a 10 percent bleach-water solution.

iv. Disposal Policy

A. Chipping or shredding the wood from infected trees to use as mulch is an acceptable means of recycling the wood. Chipping or shredding allows the wood to dry out quickly, thereby killing the fungus.

B. Burning diseased wood is an acceptable means of disposal. Burning diseased logs will kill the fungus, and the fungus will not spread with the smoke.

C. Logs from diseased Red Oaks, that are not chipped, shredded, or burned shall be disposed of at a landfill.

D. Firewood from diseased Red Oak trees shall not be stored near healthy trees where fungal spores or insects that carry the spores have the potential to spread the fungus to healthy trees. It is recommended to store oak firewood under a sheet of clear plastic, tightly sealing the edges of plastic with soil or bricks. Doing so will prevent any spore carrying beetles from escaping and will solarize and heat the stored firewood to speed the drying process. It is also recommended to use clear plastic, as black plastic will reveal any escape holes to the beetles.

E. In situations where diseased Red Oak trees are identified and are not accessible for chipping, shredding, or removal, the trunk of the diseased tree should be girdled, and the stem treated with an appropriate herbicide to deaden the tree and hasten the desiccation and drying of the wood below the minimum moisture content that could support the development of fungal spores.

4. Payment

Payment for this item shall be subsidiary to the Right-of-Way Preparation item.

170 - Protective Coatings

1. Description

This item shall govern the application of protective coatings for wastewater systems, where indicated on the drawings or required by the location, such as force main termination manholes, lift station wet wells, exposed lift station piping, etc.

2. Coating Systems

Table below shows categories of item to be coated and options of coating system to use.

Table 170.1	
Item to be Coated	**Coating System**
New or existing above ground and non-submerged metallic piping and valves (non-galvanized)	1, 2, or 3
New or existing submerged structural steel and piping (when exposed from dewatering, non-galvanized)	3 or 4
Concrete structures	5, 6, 7 or 8

a. Polyurethane Three-Coat System.

i. Surface Preparation.

A. Protection. Vehicles, equipment, structures, or other nearby surfaces not to be coated, shall be protected from blasting products and overspray throughout all surface preparation and coating operations. Transitions into uncoated areas shall be neatly taped-off or otherwise protected.

B. Initial Cleaning. If necessary, surfaces shall be decontaminated by high-pressure water blasting, steam cleaning, or by any other method, to remove all oils, greases, scum and surface contaminants.

C. Abrasive Blast Cleaning for External Coating. Surfaces shall be cleaned as per SSPC Standard SP-10, "Commercial Blast Cleaning."

D. Cleaning of Adjacent Areas: After abrasive blasting is completed, areas adjacent to the work area shall be cleaned of dirt, blasting residues and other debris to prevent wind-blown contamination of the prepared substrate or freshly applied coatings.

E. Final Cleaning Before Application of Primer: Just prior to primer application, surfaces to be coated shall be power vacuumed to remove all dust and blasting residues. Transitions into adjacent areas not to be coated shall be neatly taped off or otherwise protected. Steel surfaces must be absolutely dry and dust-free prior to and during application of the primer.

ii. Three Coat Application. The total dry film thickness (DFT) after 5 days shall be 9 to 13 mils for metallic surfaces.

A. First Coat. First coat with zinc rich epoxy or organic zinc primer @ 3 to 4mils DFT.

B. Second Coat. Second coat with chemical resistant epoxy @ 4 to 6 mils DFT.

C. Third Coat. Third coat with UV stable polyurethane topcoat @ 2 to 3 mils DFT.

b. Premium Epoxy Coating System.

i. Surface Preparation.

A. Protection. Vehicles, equipment, structures, or other nearby surfaces not to be coated, shall be protected from blasting products and overspray throughout all surface

preparation and coating operations. Transitions into uncoated areas shall be neatly taped-off or otherwise protected.

B. Initial Cleaning. If necessary, surfaces shall be decontaminated by high pressure water blasting, steam cleaning or by any other method to remove all oils, greases, scum and surface contaminants.

C. Decontamination. Surfaces previously exposed to salts or other chemical services shall be decontaminated by high pressure fresh water blasting, steam cleaning or by any method to remove all surface contaminants and eliminate or reduce subsurface contaminants to an acceptable level. If detergents are used, they shall be completely rinsed with plenty of fresh water.

D. Abrasive Blast Cleaning for External Coating.

1). Surfaces shall be cleaned as per SSPC Standard SP-10, "Commercial Blast Cleaning."

2). Immersed surfaces to receive an external coating shall be abrasive blasted per SSPC Standard No. SP 10, "Near-White Blast Cleaning" with a 1 1/2 to 2 mil (37.5-50 micron) surface profile. Blast or grind irregular surfaces to same condition as flat surfaces. Sharp edges shall be ground down and rounded.

E. Cleaning of Adjacent Areas. After abrasive blasting is completed, areas adjacent to the work area shall be cleaned of dirt, blasting residues and other debris to prevent wind-blown contamination of the prepared substrate or freshly applied coatings.

F. Final Cleaning Before Application. Just prior to application, surfaces to be coated shall be power vacuumed to remove all dust and blasting residues. Transitions into adjacent areas not to be coated shall be neatly taped off or otherwise protected. Steel surfaces must be absolutely dry and dust-free prior to and during application of the coating.

G. Concrete surfaces to be coated that are subject to immersion conditions shall be abrasive blast cleaned per ASTM D4259, Abrading Concrete, to provide a minimum height profile of 5 to 8 mils. Blasting must produce an even profile, free of loose aggregate, weak matrix, crusts, dusting and other contaminants.

ii. Two Coat (Primer-less) Application (to be used only on indoor applications). The total dry film thickness (DFT) after 5 days shall be 40 mils for concrete, masonry or immersed metallic surfaces.

iii. First Coat. First coat with flake-filled premium epoxy @ 20 mils dry film thickness.

iv. Second Coat. Second coat with flake-filled premium epoxy @ 20 mils dry film thickness.

v. Three Coat Application (required for outdoor applications). The total dry film thickness (DFT) after 5 days shall be 9 to 13 mils for metallic surfaces.

A. First Coat. First coat with zinc rich epoxy or organic zinc primer @ 3 to 4 mils dry film thickness.

B. Second Coat. Second coat with chemical resistant epoxy @ 4 to 6 mils dry film thickness.

C. Third Coat. Second coat with UV stable polyurethane topcoat @ 2 to 3 mils dry film thickness.

c. Fusion Bonded Epoxy Coating

i. Surface Preparation. In accordance with coating manufacturer’s recommendations.

ii. Application. In accordance with coating manufacturer’s recommendations.

d. Coal Tar Epoxy

Surface Preparation

A. Protection. Vehicles, equipment, structures, or other nearby surfaces not to be coated, shall be protected from blasting products and overspray throughout all surface preparation and coating operations. Transitions into uncoated areas shall be neatly taped-off or otherwise protected.

B. Initial Cleaning. If necessary, surfaces shall be decontaminated by high pressure water blasting, steam cleaning or by any other method to remove all oils, greases, scum and surface contaminants.

C. Decontamination. Surfaces previously exposed to salts or other chemical services shall be decontaminated by high pressure fresh water blasting, steam cleaning or by any method to remove all surface contaminants and eliminate or reduce subsurface contaminants to an acceptable level. If detergents are used, they shall be completely rinsed with plenty of fresh water.

D. Abrasive Blast Cleaning per SSPC Standard No. SP 10, "Near-White Blast Cleaning" with a 1 1/2 to 2 mil (37.5-50 micron) surface profile. Blast or grind irregular surfaces to same condition as flat surfaces. Sharp edges shall be ground down and rounded. If flash rust develops, all traces shall be removed by abrasive sweep blast before priming.

E. Cleaning of Adjacent Areas. After abrasive blasting is completed, areas adjacent to the work area shall be cleaned of dirt, blasting residues and other debris to prevent wind-blown contamination of the prepared substrate or freshly applied coatings.

F. Final Cleaning Before Application of Coating. Just prior to primer application, surfaces to be coated shall be power vacuumed to remove all dust and blasting residues. Transitions into adjacent areas not to be coated shall be neatly taped off or otherwise protected. Steel surfaces must be absolutely dry and dust-free prior to and during application of the primer.

ii. Application. The total dry film thickness after 5 days shall be 20 mils.

A. One Coat (Primer-less). 20 mils dry film thickness.

e. Raven 405 System.

i. Surface Preparation.

A. Protection. Vehicles, equipment, structures or other nearby surfaces not to be coated shall be protected from blasting products and overspray throughout all surface preparation and coating operations. Transitions into uncoated areas shall be neatly taped-off or otherwise protected.

B. New Concrete.

1). Concrete should be floated free of sharp edges, ridges or depressions. All structural cracks shall be repaired, voids filled and slopes reestablished. New concrete must be allowed to cure for a minimum of 28 days prior to applying a protective lining system. This usually is sufficient time to allow for shrinkage and for new concrete pours to dissipate a sufficient amount of moisture.

2). Moisture Testing. New concrete should be installed over a moisture barrier to eliminate moisture transmission through the concrete floor. Prior to the application of materials, the moisture content must be determined using a suitable Moisture Detection System such as that manufactured by Sealflex Industries, 2925 College Ave., #B4, Costa Mesa, CA (714-708-0850). An average value exceeding 3.0 lbs./1000 ft^2/24-hour period is unacceptable and will require additional cure time, the application of a surface penetrating vapor barrier or other corrective measures. Retest after taking corrective measure to ensure an average value below 3.0 pounds.

3). All concrete structures to receive lining system must be properly designed and capable of withstanding imposed loads. Surfaces must be dry, firm, free of laitance, form release agents, standing water and have attained 3000 psi compressive strength or be structurally sound as determined by Engineer. The cleaning of contaminants may be attained by a chemical cleaner such as CHLOR*RID with NO rinse.

4). Abrasive blast to expose fine aggregate, using a shot-blasting machine or standard sandblasting equipment, with a safe pressure, approximately 60-70 psi at a straight bore nozzle. Surface preparation requirement is to obtain a uniform surface texture resembling an ICRI CSP #5 comparator, minimum. (Note: ICRI = International Concrete Repair Institute.)

C. Old Concrete.

1). All concrete structures to receive lining system must be capable of withstanding imposed loads. All oil, grease and chemical contaminants must be removed from the surface of concrete by chemical cleaning. The cleaning of contaminants may be attained by a chemical cleaner such as CHLOR*RID with NO rinse. Surfaces must be firm, free of standing water, laitance, form release agents, and be structurally sound as determined by Engineer.

2). Abrasive blast to expose fine aggregate. Use a shot-blasting machine or standard sandblasting equipment, with a safe pressure, approximately 60-70 psi at a straight bore nozzle. Surface preparation requirement is to obtain a uniform surface texture resembling an ICRI CSP #5 comparator, minimum. (Note: ICRI = International Concrete Repair Institute.)

ii. Application.

A. 100% solids, solvent-free epoxy grout that can be troweled or sprayed and specifically formulated for optimum epoxy top-coating compatibility. The epoxy grout manufacturer shall provide instructions for epoxy top-coating procedures.

1). Cementitious repair materials shall be troweled to provide a smooth surface with an average profile equivalent to coarse sandpaper to optimally receive the protective coating. No bugholes or honeycomb surfaces should remain after the final trowel procedure of the repair mortar.

2). Repair materials shall be used to fill voids, structurally reinforce and/or rebuild surfaces, etc. as determined necessary by the Engineer and protective coating applicator. Repair materials must be compatible with the specified epoxy coating and shall be applied and cured in accordance with the manufacturer’s recommendations.

3). For lift station applications, apply coating on all wall, floor and ceiling surfaces. For all other applications, apply coating from top of structure to one (1)-foot below minimum water surface elevation.

B. Raven Lining Systems' Raven 405 coating system

1). Raven Lining Systems' Raven 405 coating system - a 100% solids, solvent-free two-component epoxy resin system thixotropic in nature and filled with select fillers to minimize permeability and provide sag resistance

2). Airless spray application equipment approved by the coating manufacturer shall be used to apply each coat of the protective coating.

3). The spray equipment shall be specifically designed to accurately ratio and apply the specified protective coating materials and shall be regularly maintained and in proper working order.

4). Installation. Specified surfaces shall be coated by spray application of Raven 405 0 moisture tolerant, solvent-free, 100% solids, epoxy protective coating. Spray application shall be to the following wet film thickness: 100 mils minimum thickness

C. Contractor Prequalification.

1). Raven Lining Systems' certification that Applicator has been trained and approved in the handling, mixing and application of the products to be used.

2). Certification by Raven Lining Systems that the equipment to be used for applying the products has been approved and Applicator personnel have been trained and certified for proper use of the equipment

3). Two (2) years' experience and five (5) recent references of projects of similar size and scope and Applicator must provide references indicating successful application on underground concrete or masonry substrates of a minimum 5,000 sf of Raven Lining Systems' 100% solids, high-build solvent-free epoxy coating by heated, plural component spray application.

f. SewerGard No. 210S System.

i. Surface Preparation.

A. Protection. Vehicles, equipment, structures or other nearby surfaces not to be coated shall be protected from blasting products and overspray throughout all surface preparation and coating operations. Transitions into uncoated areas shall be neatly taped-off or otherwise protected.

B. New Concrete.

1). Concrete should be floated free of sharp edges, ridges or depressions. All structural cracks shall be repaired, voids filled and slopes reestablished. New concrete must be allowed to cure for a minimum of 28 days prior to applying a protective lining system. This usually is sufficient time to allow for shrinkage and for new concrete pours to dissipate a sufficient amount of moisture.

2). Moisture Testing. New concrete should be installed over a moisture barrier to eliminate moisture transmission through the concrete floor. Prior to the application of materials, the moisture content must be determined using a suitable Moisture Detection System such as that manufactured by Sealflex Industries, 2925 College Ave., #B4, Costa Mesa, CA (714-708-0850). An average value exceeding 3.0 lbs./1000 ft2/24-hour period is unacceptable and will require additional cure time, the application of a surface penetrating vapor barrier or other corrective measures. Retest after taking corrective measure to ensure an average value below 3.0 pounds.

3). All concrete structures to receive lining system must be properly designed and capable of withstanding imposed loads. Surfaces must be dry, firm, free of laitance, form release agents, standing water and have attained 3000 psi compressive strength or be structurally sound as determined by Engineer. The cleaning of contaminants may be attained by a chemical cleaner such as CHLOR*RID with NO rinse.

4). Abrasive blast to expose fine aggregate, using a shot-blasting machine or standard sandblasting equipment, with a safe pressure, approximately 60-70 psi at a straight bore nozzle. Surface preparation requirement is to obtain a uniform surface texture resembling an ICRI CSP #3-5 comparators. (Note: ICRI = International Concrete Repair Institute.)

C. Old Concrete.

1). All concrete structures to receive lining system must be capable of withstanding imposed loads. All oil, grease and chemical contaminants must be removed from the surface of concrete by chemical cleaning. The cleaning of contaminants may be attained by a chemical cleaner such as CHLOR*RID with NO rinse. Surfaces must be firm, free of standing water, laitance, form release agents, and be structurally sound as determined by Engineer.

2). Abrasive blast to expose fine aggregate. Use a shot-blasting machine or standard sandblasting equipment, with a safe pressure, approximately 60-70 psi at a straight bore nozzle. Surface preparation requirement is to obtain a uniform surface texture resembling an ICRI CSP #3-5 comparators. (Note: ICRI = International Concrete Repair Institute.)

ii. Application.

A. Epoxy Filler Compound No. 209. Used for filling bug holes, static cracks and joints and for general concrete patching.

1). Mixing. Add contents of hardener to liquid and mix with a slow-speed paddle or "Jiffy" mixer for 1 minute until thoroughly blended. Add the powder gradually while mixing with same slow-speed mixer to obtain a uniform consistency. Mix only complete batches. Material which has begun to set must be discarded. Do not try to re-temper the material.

2). Installation. To maximize working time, spread mixed No. 209 onto a plasterer's hawk upon completion of the mixing. Apply No. 209 to concrete with a smooth plasterer's rubber float. After application, excess material must be removed by using the edge of the float or squeegee.

3). For lift station applications, apply coating on all wall, floor and ceiling surfaces. For all other applications, apply coating from top of structure to one (1)-foot below minimum water surface elevation.

B. SewerGard No. 210S. Corrosion-resistant, spray-applied epoxy lining.

1). No. 210S is a two-component product, packaged in premeasured containers consisting of liquid and hardener.

2). Remix contents of liquid component for a minimum of 2 minutes with a "Jiffy" type mixer.

3). Remix contents of the hardener by shaking; then add to liquid and mix for a minimum of 3 minutes until thoroughly blended.

4). Mix only complete batches. Material which has begun to set must be discarded. Do not try to re-temper the material.

5). Installation. SewerGard No. 210S is applied by spray method to a thickness of 60 mils. Theoretical coverage is 90.5 square feet per unit at 60 mil thickness. Coverage is theoretical and will vary depending upon surface conditions, porosity, application techniques and project specifics.

C. Contractor Prequalification.

1). Sauereisen No. 210S System Applicators. Each applicator who is to apply the No. 210S system must be tested prior to proceeding with the installation of materials, in order to determine qualification and skill. This prequalification test will be conducted to ensure that the materials will be applied in a manner that will produce a strong, uniform, well-bonded, holiday-free lining.

2). No. F-120/209. A 3' x 5' concrete panel will be used for each applicator. The surface of the concrete must be properly prepared for the applicator as outlined in this

specification. The applicator must show competency in applying both products per the specification in regards to mixing, application techniques, cleanup and safety precautions.

3). The No. 210S must be applied in one coat to a minimum 60-mil thickness and must be uniform in appearance and thickness. SewerGlaze must be applied in one coat to a minimum thickness of 8 mils and must be uniform in appearance and thickness. The applicator must show competency in spray applying epoxy systems, including but not limited to mixing, application techniques, cleanup and safety precautions.

g. Chesterton ARC 791 System

i. Surface Preparation.

A. All surface preparation shall be the responsibility of the coating installer and shall be fully responsible for all aspects of preparation of substrate. Repairs, cracks, joints blasting, cleaning and testing.

B. All surfaces to receive coating shall be dry abrasive blasted to minimum profile equal to ICRI CSP #6.

C. All terminations (walls, floors, gates, pipe, and doors etc. shall be keyed in to prohibit corrosion at seams and under coating gas migration.

D. All leaking cracks shall be injected with suitable manufacturer approved urethane leak stop material by the certified coating applicator.

E. All active cracks shall be treated as an expansion joint as detailed in ARC procedural guide and addressed by the certified coating applicator.

F. When required rebar replacement and manufacturer approved concrete repair mortar shall be applied by certified coating installer.

ii. Application.

A. Concrete repair mortar shall be manufactured and/or approved by coatings manufacturer and/or supplied by same. All repair materials/mortar shall be installed by coatings Manufacture, Certified applicator.

B. Do not apply under conditions that are unsuitable for the production of good results. Do not begin application of coatings in areas where other trades are working, or where construction activities result in airborne dust or other debris. Do not apply coatings in conditions which do not conform to the recommendations of coating manufacturer.

C. Coatings shall only be applied when conditions fall within the parameters listed in manufacturer's printed data.

D. Applicator's Qualifications

1). Must be qualified in this line of work and have at least ten (10) years documented experience in concrete repair/restoration.

2). Must have a minimum of ten (10) years documented experience in the application of the protective coatings specified herein.

3). Must have a minimum of ten (10) years of documented successful installations of the specified products, on structures and/or equipment similar to this project.

4). Submit a list of (5) recent projects of the same structures and names and contact information of references.

5). Applicator must be Manufacturer certified for 5 years prior to bid submission.

6). Applicator must have minimum (5) years' experience with installation of concrete repair mortar and rebar replacement.

7). Applicator must have NACE ll certified inspector on staff at all times to conduct all testing as required in section (1.02 C) of specifications.
8). Applicator must use own employees for all work, no subcontractors shall be permitted.

E. Primer ARC 797
1). Two component primer.
2). Primer must be chemically unique from the top coat matrix.
3). Primer must provide a recoat window of not less than 2 hours at 77°F.
4). Primer shall be hydrophobic, moisture insensitive, have a low viscosity and be able to bond to wet concrete.

F. Trowel-on ARC 791 Quartz-Reinforced Composite Coating
1). Mixing:
a). Material temperatures shall be between 70 and 90°F to facilitate mixing and application.
b). Premix Part A to disperse pigments.
c). Thoroughly mix Part A and Part B in a suitable pail, using a slow speed mixer.
d). Transfer the blended resins to a mortar mixer and gradually add the quartz reinforcement.
e). Mix for 3 minutes or until uniformly blended.

2). Apply trowel-on quartz-reinforced composite shortly after application of primer while primer is still wet or tacky. This is normally within approximately 4 hours of primer application.
3). If the area to be coated is not wet or tacky, re-prime the area.
4). Minimum application temperature is 50°F, recommended application temperature is 77°F.
5). Apply single coat at 250 mils dry film thickness (DFT).
6). Horizontal surfaces (floors):
a). Distribute over floor surface using screed guides and rigid bar, or screed box, not exceeding 4 feet wide.
b). Rough screed a minimum of 0.25 inches and finish the surface using steel trowels.
c). Large horizontal areas may be power troweled to achieve the required flatness and finish.

7). Vertical surfaces:
a). Apply to vertical surfaces using a hawk and trowel, pressing the top coat firmly onto the surface to promote contact with the primer.
b). Finish the surface to the desired texture with a trowel.
c). Remove all trowel marks and unevenness before the end of the “Working Time”.

d). Curing Schedule:

Table 170.2				
	50°F	60°F	77°F	90°F
Foot Traffic	16 hrs.	9 hrs.	6 hrs.	4.5 hrs.
Light Load	24 hrs.	19 hrs.	11 hrs.	8.5 hrs.
Full Load	72 hrs.	42 hrs.	24 hrs.	19 hrs.
Full Chemical	19 days	13 days	7 days	5 days

Note: Cure times are based on substrate temperature and thickness of 0.25 inches. Thicker films will cure more rapidly.

e). Provide adequate lighting at any location that coatings are being applied or testing is performed. Illumination shall be of sufficient intensity to achieve good results. Provide explosion-proof lighting when required.

f). Temporary ladders and scaffolds shall conform to applicable safety requirements. Erect temporary scaffolds where needed to cover large areas. Provide ladders or scaffolding during testing procedures.

iii. Quality Control

A. The cured composite must meet the following physical requirements:
   1). Compressive Strength (ASTM C579): 9.320 psi
   2). Tensile Strength (ASTM C307): 2,850 psi
   3). Flexural Strength (ASTM C580): 5,500 psi
   4). Flexural Modulus of elasticity (ASTM C 580) 1.87 X 106 psi.

B. Composite shall be able to hold a minimum of 0.25 inches thick on vertical surfaces without sag at temperatures of up to 80°F.

C. Composite must have a working time of at least 45 minutes at 77°F.

D. Maximum service temperature:
   1). Continuous: 150°F
   2). Intermittent: 200°F

E. Protective coatings shall be applied under quality control procedures that include the following test procedures certified by NACE Level ll inspector.

F. Pre-Installation Testing
   1). Surface profile test using Elcometer 224 surface profile gage or equal, to ANSI/NACE/ICRI standards for specified substrate. CSP 9 for trowel applied,
   2). pH testing for acidification of concrete (ASTM D 4262) Utilize WTW 3310 pH meter or approved equal.
   3). Chloride testing for soluble salts using Hedon Automated Soluable Salt Meter or approved equal.
   4). Ultraviolet light testing for hydrocarbon residues shall be conducted on all surfaces to be coated.
   5). Moisture vapor transmission testing (ASTM D 4263) not to exceed 5 lbs./1000 Sq. Ft./24hrs. Must use Elcometer 7410 Moisture Meter or approved equal.

G. Post-Installation Testing
   1). Delamination detection shall be conducted on all surfaces using an Albion 875-1 delamination detection tool.

2). High voltage spark testing on all coated surfaces for pinhole/holiday free verification (100 volts/mil) must use Tinker & Rasor Model AP/W, or approved equal.
3). Dolly pull off adhesion testing shall be performed only when delamination is detected using DeFelsko PosiTest AT-A pull off adhesion tester, or approved equal. (1 dolly per 750 sq. ft.)
4). Cured coating shall have thickness confirmed must use Elcometer NDT CG70ABDL Ultrasonic Thickness Gauge or approved equal.

h. Con Shield
   i. Application
      A. Antimicrobial additive, Con Shield®, shall be used to render the concrete uninhabitable for bacteria growth.
      B. The liquid antibacterial additive shall be an EPA registered material.
      C. The amount to be used shall be as recommended by the manufacturer. This amount shall be included in the total water content of concrete mix design.
      D. The additive shall be added into the concrete mix water to ensure even distribution of the additive throughout the concrete mixture.
      E. The antibacterial shall be used by factory certified precast concrete plants. Acceptance from the precast manufacturer shall be in the form of a letter of certification stating that the correct amount and mixing procedure were followed.

3. Coating Execution

a. Work Conditions
   i. Weather. No coating or painting shall be applied:
      A. when the surrounding air temperature or the temperature of the surface to be coated or painted is below 50 F;
      B. to wet or damp surfaces or in rain, snow, fog or mist;
      C. when the temperature is less than 5 F above the dew point;
      D. when it is expected the air temperature will drop below 50 F or less than 5 F above the dew point within 8 hours after application of coating or paint.
      E. Dew point shall be measured by use of an instrument such as a Sling Psychrometer in conjunction with U.S. Department of Commerce Weather Bureau Psychrometric tables.
      F. If preceding conditions are prevalent, coating or painting shall be delayed or postponed until conditions are favorable. The day's coating or painting shall be completed in time to permit the film sufficient drying time prior to damage by atmospheric conditions.
      G. These weather conditions shall be adhered to unless otherwise specified under individual coating systems.
   ii. Surface. If surfaces to be painted cannot be put in proper condition for painting by customary cleaning and abrasive operations, promptly notify Owner’s Inspector. Contractor shall assume responsibility for and rectify any unsatisfactory finish resulting from application to an unsatisfactory surface. Do not apply paint to a wet or damp surface.
   iii. Equipment. The Contractor's coating and painting equipment shall be designed for application of the materials specified and shall be maintained in good working order comparable to that described in printed instructions of the coating manufacturer. Clean equipment thoroughly before and after use with the appropriate cleaning solution indicated

by the coating manufacturer. All gauges and controls on spray equipment shall be in proper working order at all times and the gauges must be operational and readable.

iv. Warnings. Display caution signs in necessary areas advising of spray painting and warning against open flames.

b. Surface Preparation

i. Solvent Cleaning. Remove oil, grease, soil and other contaminants by use of solvents, emulsions, cleaning compounds, steam cleaning, or similar materials and methods which involve a solvent or cleaning action, in accordance with SSPC SP 1.

ii. Grinding. Remove weld splatter and rough edges and grind rough welds so that all surfaces are in proper condition to receive the specified coating. Prepare all welds that will be immersed as per NACE RP0178, Designation D.

iii. Abrasive Blast Cleaning.

A. Use a source that provides compressed air, free of detrimental amounts of water and oil. The compressor shall, as a minimum, be capable of delivering a pressure at the blast nozzle of at least 90 psig; the blast nozzle shall be of the venturi type.

B. Abrasively clean only those areas that can be primed the same day or before any rust starts to form, whichever occurs first. Areas which are not painted the same day must be cleaned again on the day the prime coat is applied. Remove the abrasive material from surface by brush or industrial vacuum.

1). Power Tool Cleaning. Metalwork in which SP 6 or SP 10 cannot be accomplished shall be cleaned in accordance with SSPC-SP11, Power Tool Cleaning to Bare Metal, providing an angular profile.

2). Shop Priming. Where metalwork, equipment, valves and the like are shop primed, the primer used must be compatible with the coating system to be applied in the field. All information shall be furnished regarding the shop prime coat and, if not compatible with succeeding coats, the shop prime coat shall be removed by abrasive blast cleaning.

3). Unknown or Non-Compatible Materials. Items coated with an unknown paint system, or a primer or system which is not compatible with the specified system, shall be blast cleaned and recoated with the specified coating system at the job site. When abrasive blast cleaning is not feasible, the Contractor shall notify the Owner's Inspector and request permission to apply a barrier coat over the unknown or non-compatible material. The proposed barrier coat must be recommended in writing by the paint system manufacturer and is subject to review by the Engineer. Following application of the barrier coat, if permitted, the specified coating system shall be applied. Minimum dry film thickness shall be increased an amount equal to the barrier coat and unknown or non-compatible coats.

c. Coating Application

i. Manufacturer's Representative. The coating manufacturer will be responsible, through an authorized representative, to provide technical assistance to the paint contractor as needed.

ii. Workmen. Employ workmen skilled in structural steel, piping, and mechanical equipment painting.

iii. Materials.

A. Coating materials, abrasive, and equipment used in painting and abrasive cleaning are subject to inspection at any time by the Owner's Inspector.

B. Remove blasting material and dust from the surface to be painted before paint application is begun.

iv. General Application Requirements.

A. Prepare all surfaces to receive materials as required herein or as required by the coatings manufacturer. Clean surfaces to remove all foreign matter. Roughen surface as recommended by the coating manufacturer for proper adhesion of coating to the substrate.

B. Items to be attached to similar or dissimilar materials shall be back coated as specified for the exposed surfaces of those items. Mask or protect finished surfaces in area being coated. Remove, replace, and protect finished items adjacent to surfaces to be coated. Reinstall items when painting is complete.

C. Mix and apply materials in accordance with the manufacturer's printed instructions. Allow each succeeding coat to dry in accordance with manufacturer's printed instructions.

D. Include painting of engaged and free-standing columns or similar items when painting walls.

E. Do not paint code required labels, (Underwriters Laboratories, Inc., Factory Mutual, or the like) or any equipment identification, performance ratings, name, or nomenclature plates. Remove any paint inadvertently applied to such items.

F. Protect adjacent walls, floors, and ceilings against splash or overspray. Remove materials from surfaces not designated to receive such materials.

G. Remove waste rags and coating debris on a daily basis. Keep storage spaces and work areas neat and clean.

v. Paint Coating Methods.

A. Stripe coat all welds. Apply stripe coat by brush and scrub into all weld areas; then apply prime coat to entire surface, including weld areas, by spray, roller or method selected.

B. Coat areas with a uniform film, free of sags, runs, or brush marks. Where multiple coats of paint are specified, apply each coat in a different color which complements the following coat and is different than the preceding coat. Each coat must be free of shadows and uniform in appearance.

C. Except where otherwise specified, thin paint only as necessary for workability of coating material in accordance with manufacturer's printed instructions. Use only an appropriate thinner as recommended by the paint manufacturer.

D. When paint is being applied to interior of wet well or any other closed areas, provide adequate ventilation.

E. Comply with recommendations of the paint manufacturer in regard to drying time for each coat, technique of spray application, ventilation, paint thinning, and safety precautions. The Contractor must fully inform all members of his field crew of these recommendations.

F. Where inspection shows that the specified thickness is not developed, apply additional coats in accordance with the manufacturer's surface preparation and cure schedule requirements to produce the required film thickness.

G. Repair and recoat improper applications as recommended by the manufacturer or as required by the Owner’s Inspector.

H. Factory finished items shall be protected against damage during transit, storage and erection. Damaged areas must be refinished as the original so that at the end of the project the finish on all items will be in like new condition. The following items shall receive final finish at the factory.
   1). Electrical panels (to be factory painted ANSI No. 61 gray).
   2). Light fixtures.
   3). Pressure gauges.
   4). Instrumentation.
   5). Similar equipment with standard factory finish, subject to Owner's review.

I. The following items shall not be painted unless otherwise specified:
   1). Aluminum, brass, bronze, chrome, copper, stainless or galvanized steel.
   2). Nameplates or serial numbers.
   3). Grease fittings.
   4). Valve operator stems.
   5). Buried or encased piping or conduit.
   6). Concrete floors and slabs not exposed to wastewater.
   7). Glass.

vi. Cleaning. Upon completion of the work, remove all staging and scaffolding. Dispose of all used sand, containers and rubbish in a suitable manner. Remove paint spots, oil or stains on adjacent surfaces. Leave the entire job clean and acceptable.

4. Coating Inspection and Testing

a. Inspection.

i. The Contractor shall provide OSHA approved staging, scaffolding and lighting as required to facilitate proper inspection.

ii. Surface preparation, coating application and repairs are subject to inspection by Owner's Inspector. The standards published by the Steel Structures Painting Council, especially SSPC VISL 635, Pictorial Surface, will be used as guides for acceptance or rejection of the cleaning, painting or coating application. Particular attention will be given hard to reach areas, bolted connections, supports, anchor bolts and threaded joints.

iii. A magnetic type dry film thickness gauge and an electrical holiday detector will be used to determine the acceptability of the paint application. Calibration of the magnetic thickness gauge will be done on the site using the U.S. Department of Commerce, Bureau of Standard Film Thickness Calibration Standards.

iv. Give sufficient notice in advance of coating applications such that Owner's Inspector can perform the following:
   A. Examination and approval of surface preparation prior to any coating.
   B. Examination and approval of each coat prior to application of the next coat.
   C. Inspection of the completed coating for runs, overspray, roughness, and any evidence of improper application.
   D. Direction or observation of testing.

b. Testing.

i. The following tests will be conducted:
   A. Dry film thickness will be tested after each coat of interior and exterior paint has been applied and after final coat of the exterior system has been applied.

B. A test shall be made for every 25 square feet of surface area and at other locations specified by the Owner's Inspector.

C. All paint systems will be tested for holidays after the final coat has been applied.

ii. Should any paint system fail to pass a test, Contractor will remove defective coating system, reapply and subsequently retest the coating system.

5. Payment

Payment for Protective coatings shall be considered subsidiary to the item on which the coating is to be applied.

Specifications 200-299: Concrete

200 - Concrete

1. Description

The requirements of this item shall govern for all concrete for structures, curb and gutter, and incidentals or miscellaneous construction.

Concrete shall be composed of Normal Portland Cement or High Early Strength Cement, coarse aggregate, fine aggregate and water proportioned and mixed as hereinafter provided in these specifications.

2. Materials

a. Cement

Only one brand of cement shall be used in any one (1) structure, except by written permission of the City Engineer. When such permission is granted and more than one (1) brand is used in one (1) structure, the resulting concrete shall be uniform in color.

Portland Cement shall meet the requirements of the current Standard Specifications for Portland Cement of the ASTM Designation C-150, Type I, II or III. If the cement could be exposed to sewage, ASTM C-150 Type V shall be used.

All cement shall be sampled and tested in accordance with the current Standard Methods of Sampling and Testing Portland Cement of the ASTM Designation C-183, C-188, and C-191.

b. Mixing Water

Water for use with cement shall be clean and free from injurious amounts of oil, acid, alkali, salt, organic matter or other deleterious substances. Water from doubtful sources shall not be used until tested and approved.

Water which is suitable for drinking or for ordinary household use may be accepted for use without being tested.

c. Coarse Aggregate

Coarse aggregate shall consist of gravel or crushed stone meeting the requirements of the current ASTM Specifications C-33.

Unless otherwise indicated, use following ASTM standard sizes: No. 357 or No. 467; No. 57 or No. 67, No. 7. Maximum size: Not larger than 1/5 of narrowest dimension between sides of forms, nor larger than 3/4 of minimum clear spacing between reinforcing bars.

d. Fine Aggregate

Fine aggregate shall consist of natural sand, manufactured sand, or a combination thereof, conforming to the current ASTM Specification C-33.

When tested in accordance with the Standard Method of Test of Organic Impurities in Fine Aggregates for Concrete, ASTM Designation C-40, the fine aggregate shall not show a color darker than the standard color.

Unless otherwise indicated, use following ASTM standard sizes: 3/8”; No. 4, No. 16, and No. 100. Maximum size: Not larger than 1/5 of narrowest dimension between sides of forms, nor larger than 3/4 of minimum clear spacing between reinforcing bars.

e. Concrete Admixtures

Admixtures shall be manufactured by a company on the TxDOT approved manufacturer list.

i. Water Reducing Agent shall conform to ASTM C-494 Type A, and shall have a dosage as recommended by the manufacturer.
ii. Water Reducing and Retarding Agent: When, in the opinion of the Engineer, the ambient or concrete temperature requires the use of a water reducing and retarding admixture, such admix shall conform to ASTM C-494, Type D.
iii. Air Entraining Admixture shall be used where specified or directed to improve workability and increase resistance to freeze and thawing, and scaling. The admix shall comply with ASTM C 260 and shall be used in accordance with manufacturer's recommendations.

The total air content of the concrete shall be three (3) percent to six (6) percent.

f. Curing and Sealing Compound

All concrete shall be cured and sealed with a continuous acrylic membrane forming compound meeting the requirements of ASTM C-309. Curing compound shall be applied as soon as practical after placement of concrete and shall be used in accordance with the manufacturer's recommendations. Products shall be those on the TxDOT approved Manufacturer's list.

g. Bonding Agent

Bonding agent shall be a liquid polymer latex compound such as Daraweld-C manufactured by W.R. Grace and Company, or an approved equal.

h. Reinforcing Steel

i. Bar Steel: All bar reinforcement shall be open hearth new billet steel of structural, intermediate, or hard grade. New billet steel shall conform to the requirements of the latest Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement, ASTM Designation A-615.

Unless otherwise shown on the plans, all reinforcing bars shall be deformed bars. Twisted bars are not considered as deformed bars and will not be used. The form of deformed bars shall be such as to provide a net sectional area at all points equivalent to that of the plain round bars of equal nominal size.

ii. Wire Fabric: Wire for fabric reinforcement shall be cold-drawn from rods hot rolled from open hearth billets. Wire shall conform to the requirements of the latest Standard Specification for Carbon-Steel Wire and Welded-Wire Reinforcement, Plain and Deformed, for Concrete, ASTM Designation A-1064.

i. Pre-molded Expansion Joint Filler

Pre-molded Expansion Joint Filler shall conform to the requirements of ASTM Designation D-994 or other as approved by City Engineer.

3. Equipment

The Contractor shall obtain the Inspector's approval of all concrete mixing, handling, and transporting equipment before any pour of concrete is commenced. Such approval will not relieve the Contractor of his responsibility for providing adequate equipment to carry on satisfactorily the project operations.

4. Batching and Mixing

All batching and mixing of concrete materials shall conform to ACI 304-73 "Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete." All materials shall be measured

separately and accurately and batches shall be uniform. The coarse and fine aggregate shall be measured or weighed, loose and separately.

When transit mix concrete is used, the delivery of concrete shall be continuous at regular and uniform intervals, without stoppages or interruptions. Discharge of the concrete delivered by truck mixers shall be within the times listed below. Concrete may be discharged after these times provided the concrete temperature and slump meet the requirements of this section.

Table 200.1		
Fresh Concrete Temperature, °F	**Max Time After Batching for Concrete Not Containing Admixtures, min.**	**Max Time After Batching for Concrete Containing Admixtures, min.**
90 and above	45	75
75 ≤ T < 90	60	90
T < 75	90	120

Note: Admixtures are those identified in TxDOT Item 421 as Type B and D. Concrete must contain at least the minimum manufacturer's recommended dosage of Type B or D admixture.

5. Consistency

In general, the consistency of concrete mixtures shall be such that:

a. The mortar will cling to the coarse aggregate.
b. The aggregate will not segregate in the concrete when it is transported to the place of deposit.
c. The concrete and mortar will show no free water when removed from the mixer.
d. The surface of the finished concrete will be free from a surface film of "laitance."

Any concrete mix failing to meet the above outlined consistency requirements, although meeting the slump requirements, will be considered unsatisfactory, and the mix shall be changed to correct such unsatisfactory conditions.

6. Concrete Classification

Concrete shall be proportioned as determined by the Inspector. The total volume of materials in the concrete mixture shall be so regulated that the cement content per cubic yard of concrete shall not be less than the minimum specified for that class of concrete.

a. The concrete shall be uniform and workable and the minimum cement content, maximum water content, and the maximum slump for the various classes of mixes shall conform to TxDOT 421, or latest revision thereof, Class A, B or S. The design strength of each class is shown below. The max water to cement ratio, acceptable coarse aggregate grades, and acceptable slump range shall be per TxDOT 421.

Table 200.2	
Class	**Design strength f'_c (psi)**
A	3,000
B	2,000
S	4,000

The maximum amount of coarse aggregate (dry loose volume) per cubic foot of finished concrete shall not exceed zero-point-eighty-two (0.82) cubic feet.

The maximum amount of water, as set forth in the table above, is based upon the assumption that the aggregates are in a saturated, surface dry condition.

b. The concrete mix will be designed with the intention of producing concrete which will have compressive or flexural strength equal to or greater than the following when using current ASTM Designation C-39 and C-293.
c. The following class of concrete will be used as shown, unless otherwise specified:

Table 200.3	
Class	**Use**
A	Curb, gutter, curb &gutter, conc. Retards, sidewalks, driveways, back-up walls, anchors, non-reinforced drilled shafts
B	Riprap, traffic signal controller foundations, small roadside signs, and anchors, concrete encasement
S	Bridge slabs, top slabs of direct traffic culverts, approach slabs

In order to obtain a more workable mix and denser concrete, there shall be added as a part of the concrete for Class A concrete a cement dispersing or water reducing agent conforming to ASTM Specification C-494. The agent shall be added in accordance with the manufacturer's recommendations.

The quantity of water to be used shall be determined by the Engineer and shall be such as to give a mixture containing the minimum amount of water consistent with the required workability. The quantity of water shall be varied only by the Engineer.

7. Quality of Concrete

During the process of the work the Inspector may cast test cylinders or beams for testing to maintain a check on the compressive or flexural strength of the concrete actually placed.

Test beams or cylinders shall be required for each fifty (50) cubic yards or portion thereof, placed each day. On small structures, such as manholes, inlets, culverts, wing-walls, etc., the Inspector may vary the number for small placements to tests for each twenty-five (25) cubic yards, placed over a several-day period.

8. General Construction Requirement for Concrete Structures

a. Prior to starting work the Contractor shall inform the Inspector as to the methods of construction and the amount and character of equipment he proposes to use, the adequacy of which shall be subject to the approval of the Inspector.
b. Forms and falsework to be used in the construction of the various units of a structure shall be in accordance with all governing safety requirements and shall be the responsibility of the Contractor.
c. Approval by the Inspector of construction methods, equipment, or form and falsework plans will not relieve the Contractor of responsibility for the safety or correctness of methods used, adequacy of equipment, or from carrying out the work in full accordance with the contract.

9. Concrete Delivery

The rate of delivery of transit mixed concrete shall be so arranged that a cold joint is not allowed to form between loads. Concrete shall be hauled in vehicles so constructed and operated to provide constant agitation during transportation. Concrete improperly mixed shall not be placed in the structure.

The transit mixer shall be of an approved revolving drum or revolving blade type so constructed as to produce a thoroughly mixed concrete with a uniform distribution of the materials throughout the mass and shall be equipped with a discharge mechanism which will ensure the discharging of the mixed concrete without segregation.

The mixer drum shall be water-tight when closed and shall be equipped with a locking device which will automatically prevent the discharging of the mixer prior to receiving the required number of revolutions.

The entire quantity of mixing water shall be accurately measured and controlled. Each batch shall be mixed to the consistency as described above. Any additional mixing shall be done at a slower speed specified by the manufacturer for agitation and shall be continuous until the batch is discharged.

10. Construction Joints

Construction joints shall be placed as shown on the plans unless otherwise specifically authorized by the Engineer, in which case the joints shall be so placed and formed as to least impair the strength and appearance of the structure. All construction joints shall be made on horizontal and vertical planes and formed with mortises or keys made in the concrete unless shown otherwise on the plans.

11. Forms

Nominal one (1) inch lumber surfaced to a uniform width and thickness will be permitted for general use on the various portions of structures, if backed by a sufficient number of studs and wales.

Forms shall be mortar tight, and of sufficient strength to prevent bulging between supports. Forms shall be maintained to the lines designated until the concrete is sufficiently hardened to permit form removal and until the minimum time for forms to remain in place has elapsed in accordance with ACI Standard 318-71 “Building Code Requirements for Reinforced Concrete (ASI318-71).”

Where corners occur, suitable chamfer strips shall be placed at the angle of the forms to round off or level them. All forms shall be constructed so as to permit removal without injuring the concrete. At the time of placing concrete, the forms shall be clean and entirely free of all chips, dirt, sawdust, and other extraneous matter.

For thin wall sections and other locations where access to the bottom of the forms by other methods would be cumbersome and inadequate, clean-out openings shall be provided.

Only spreaders approved by the Inspector shall be used.

Metal form ties of an approved type shall be used to hold forms in place. Such ties shall be of a type especially designed for use in connection with concrete work, and they shall have provision to permit ease of removal of the metal as hereinafter specified. The use of metal form ties of a type that are encased in paper or other materials to allow the removal of the complete tie, leaving a hole through the concrete structure, will not be permitted. Metal ties shall be held in place by devices attached to walls. Each device shall be capable of developing the strength of the tie.

All cavities produced by the removal of metal ties shall be carefully cleaned and completely filled with re-tempered sand cement mortar mixed in proportion of one to three, and the concrete shall be left smooth and even.

12. Placing Concrete

a. **General:** The Contractor shall give the Inspector at least twenty-four (24) hours advance notice that he intends to pour concrete in any unit of the structure. The mixing of concrete and placing

of same in the forms shall not be commenced until the Engineer has given his approval. No concrete shall be placed in any unit prior to completion of the form work and the placement of the reinforcing and other steel.

Where the Contractor's operations involve the placing of concrete from above directly into an excavated area or through the completion of forms, all concrete so placed shall be deposited through a vertical sheet metal or other approved pipe or tremie not less than six (6) inches nor more than ten (10) inches in diameter. The pipe shall be made in sections so that the outlet may be adjusted to proper heights during placing operations.

Concrete shall be placed in continuous horizontal layers approximately twelve (12) inches in thickness. The rate of delivery shall be so arranged that a cold joint is not allowed to form between loads. The Contractor shall avoid unauthorized construction joints by placing required portions of abutments, piers, walls, floors, slabs, columns, or superstructures in one continuous operation. As a safety precaution, openings in the forms shall be provided for the removal of laitance and other foreign material.

All concrete shall be well compacted and the mortar flushed to the surface of the forms of continuous working with concrete spading implements and mechanical vibrators of an approved type. Vibrators of the type which operate by attachment to forms or reinforcement will not be permitted. The vibrators shall be applied to the concrete immediately after deposit and shall be moved throughout the mass, thoroughly working the concrete around the reinforcement, embedded fixtures, and into the corners and angles of the forms until it has been reduced to a plastic mass. The mechanical vibrator shall not be operated so that it will penetrate or disturb layers placed previously which have become partially set or hardened. The vibration shall be of sufficient duration to accomplish thorough compaction and complete embedment of reinforcement and fixtures, but shall not be done to an extent that will cause segregation. Vibration shall be supplemented by hand spading to ensure the flushing of mortar to the surface of all forms.

b. **Foundation and Footings:** Concrete shall not be placed in footings until the depth and character of the foundation has been inspected and permission has been given to proceed.

   Concrete in deep foundations shall be placed in a manner that will avoid separation of the aggregates or displacement of the reinforcement. Suitable chutes or vertical pipes shall be provided.

   When footings can be placed in dry foundation pits without the use of cofferdams or caissons, forms may be omitted, if desired by the Contractor and approved by the Engineer, and the entire excavation filled with concrete to the elevation of the top of the footing.

c. **Weather Conditions for Placement:** No concrete shall be placed when the atmospheric temperature is at or below forty (40) degrees F (taken in the shade away from artificial heat) unless permission is given or in cases where the temperature drops below forty (40) degrees F after the concreting operations have been started.

   The Contractor shall furnish sufficient canvas and frame work or other type of housing to enclose and protect the structure in such a way that the air around the forms and fresh concrete can be kept at a temperature of not less than fifty (50) degrees F for a period of five (5) days after the concrete is placed.

Sufficient heating apparatus such as stoves, salamanders, or steam equipment and fuel to furnish all required heat shall be supplied.

d. **Installation of Pre-Molded Expansion Joint Filler** shall be made where indicated, and the filler shall extend through the entire section of the structure.

13. Finishing

a. **Slabs, Valve Vault, Tops, Etc.:** As soon as concrete placing operations have been completed for a slab section of sufficient width to permit finishing operations, the concrete shall be approximately leveled and then struck off, tamped, and screeded using a longitudinal screed. The screed shall be of a design adaptable to the use intended, shall have provisions for vertical adjustment, and shall be sufficiently rigid to hold true to shape during use.

The initial strike off shall leave the concrete surface at an elevation slightly above grade so that, when consolidation and finishing operations are completed, the surface of the slab will be at the grade elevation shown on the plans with proper allowance for finished camber when required.

Tamping and screeding operations shall be continued until the concrete is properly consolidated and the surface voids are eliminated. The surface shall then be brought to a smooth true alignment by means of longitudinal screeding, floating, belting, and/or other methods approved by the Engineer. When templates are used, they shall be of such design as to permit early removal in order to avoid construction joints and to permit satisfactory finishing at and adjacent to the site of the template.

While the concrete is still plastic, the surface shall be straight-edged by the use of a standard ten (10) foot metal straightedge. Deviations in excess of permissible variations shall be corrected. The final surface finish of the slab shall be done after the initial straight-edging, and corrective adjusting, if required, is completed, as specified hereinafter.

b. **Formed Surfaces:** Immediately after forms are removed, the formed surfaces shall be finished as follows:

i. Any honeycomb areas shall be chipped out to firm concrete and thoroughly cleaned of chips and particles of broken concrete. A bonding agent shall then be applied to the entire surface of the cavity, and the cavity packed with a relatively dry mortar of the same sand-cement ratio as the concrete mix used in the structure. The mortar shall be thoroughly compacted to ensure complete filling of the cavity and the surface struck off to match the surrounding concrete.

ii. Exterior surfaces that will be more than one (1) foot below grade will require no further finish.

iii. Exterior surfaces to be exposed to view and to a point one (1) foot below finish grade, and interior exposed surfaces, shall be finished as follows.

All fins, form marks or offsets, and other protrusions shall be removed and surface voids shall be filled or pointed with grout. After the pointing has dried sufficiently to permit rubbing, all surfaces shall be wetted and given a surface rubbing with a No. 16 Carborundum stone or an abrasive of equal quality. The rubbing shall be continued sufficiently to bring the surface to a paste, to remove all form marks and projections, and to produce a smooth dense surface without pits or irregularities. The material that has been ground to a paste shall be carefully spread or brushed uniformly over the surface and allowed to take a rest. The use of cement to form a surface will not be permitted.

c. **Floor and Slab Finishes:** Finish treatment of floors and slabs to be provided after the initial treatment specified under "A" above and shall be as follows:
   i. Sidewalks: The sidewalk shall be floated with a steel trowel to provide a smooth, burnished surface. After floating and before the finish has set, the surfaces shall be lightly brushed with a fine brush to remove the surface cement film, leaving a fine grained, smooth but sand texture.
   ii. Concrete Valleys, Driveways, Vault Tops and Floors, Etc.: After the initial treatment specified in "A" above, and after the surface has become firm, the surface shall be given a single floating with a wood float to provide a uniform surface.
   iii. Other slab surfaces shall be finished with one of the above finishes, or not finished, as otherwise specified or as approved by the City Inspector.

d. **Curing Concrete:** Immediately after finishing, all upper non-formed surfaces shall be covered with a continuous, uniform, water impermeable coating. Immediately after removal of the side and end forms of non-exposed surfaces, and after required finishing of exposed surfaces, the formed surfaces of all concrete shall receive a like coating. The solution shall be applied under pressure with a spray nozzle in such a manner as to cover the entire exposed surface thoroughly and completely with a uniform film.

   The rate of application shall be such as to ensure complete coverage, but the area covered shall not exceed two hundred (200) square feet per gallon of curing compound.

   The coating shall be sufficiently transparent and free from permanent color to result in no pronounced change in color from that of the natural concrete at the conclusion of the curing period. It shall, however, contain a fugitive dye of color strength to render the film distinctly visible on the concrete for a period of at least four (4) hours after application.

   Under normal conditions, the curing compound, after application, shall dry to touch within one (1) hour and shall dry thoroughly and completely within four (4) hours. When thoroughly dry, it shall provide a continuous flexible membrane free from cracks or pinholes and will not disintegrate, check, peel, or crack during the required curing period. If for any reason the seal is broken during the curing period, it shall be immediately repaired with additional sealing solution.

14. Flowable Fill

Flowable fill is a concrete material suitable as a backfill for utility trenches, abandoned pipes, manholes and valves. It is a heavy material and will exert a high fluid pressure against any forms, embankment, or wall used to contain the backfill.

a. Materials
   i. Cement. Furnish hydraulic cement that meets the requirements of TxDOT's DMS-4600, "Hydraulic Cement," TxDOT's Hydraulic Cement Quality Monitoring Program (HCQMP), and ASTM C-150 Type I Portland Cement. Sources not on the HCQMP or other sources to be used in combination with an approved source will require approval before use.
   ii. Fly Ash. Furnish fly ash conforming to TxDOT DMS-4610, "Fly Ash."
   iii. Chemical Admixtures. Furnish chemical admixtures conforming to TxDOT DMS-4640, "Chemical Admixtures for Concrete."
   iv. Fine Aggregate. Provide fine aggregate that will stay in suspension in the mortar to the extent required for proper flow and that meets the gradation requirements of Table 1. Test

fine aggregate gradation in accordance with TxDOT standard laboratory test procedure Tex-401-A. Plasticity Index (PI) must not exceed 6 when tested in accordance with TxDOT standard laboratory test procedure Tex-106-A.

v. Mixing Water. Potable water, free of oils, acids, alkalis, organic matter or other deleterious substances, meeting requirements of ASTM C 94.

b. Construction Methods

i. Submit a construction method and plan, including mix design and shrinkage characteristics of the mix, for approval. Provide a means of filling the entire void area, and be able to demonstrate that this has been accomplished. Prevent the movement of any inserted structure from its designated location. If voids are found in the fill or if any of the requirements are not met as shown on the plans, remove and replace or correct the problem without additional cost to the OWNER.

Unless otherwise shown on the plans, furnish a mix meeting the following requirements.

A. Strength. The compressive strength range, when tested in accordance with TxDOT standard laboratory test procedure Tex-418-A, must be between the following strength values unless otherwise directed by the Engineer or shown on the plans:

1). Low Strength. Between 80 psi and 150 psi at 28 days.
2). High Strength. Greater than 500 psi at 28 days. For emergency repairs, strength shall be greater than 50 psi at 2 hours.
3). Two specimens are required for a strength test, and the compressive strength is defined as the average of the breaking strength of the 2 cylinders.

B. Consistency. Design the mix to be placed without consolidation and to fill all intended voids. Fill an open-ended, 3-inch diameter by 6-inch-high cylinder to the top to test the consistency. Immediately pull the cylinder straight up. The correct consistency of the mix must produce a minimum 8-inch diameter circular spread with no segregation.

1). When necessary, use specialty type admixtures to enhance the flowability, reduce shrinkage, and reduce segregation by maintaining solids in suspension. All admixtures must be used and proportioned in accordance with the manufacturer's recommendations.
2). Mix the flowable fill using a central-mixed concrete plant, ready-mix concrete truck, pug mill, or other approved method.
3). Furnish all labor, equipment, tools, containers, and molds required for sampling, making, transporting, curing, removal, and disposal of test specimens. Furnish test molds meeting the requirements of TxDOT standard laboratory test procedure Tex-447-A. Transport, strip, and cure the test specimens as scheduled at the designated location. Cure test specimens in accordance with TxDOT standard laboratory test procedure Tex-447-A. The Engineer will sample, make, and test all specimens. Dispose of used, broken specimens in an approved location and manner. The frequency of job control testing will be at the direction of the Engineer.

C. Shrinkage and Bleeding. Limit shrinkage to 0.5% or less based upon the results from ASTM C 827, "Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures."

210 - Concrete Encasement, Cradles, Saddles, and Collars

1. Description

This item shall govern the placement of concrete encasements, cradles, saddles, collars on either existing or proposed water/sewer mains, when specified in the contract documents, or as directed by the Engineer or Inspector.

2. Materials

All concrete shall conform to the provisions of Section 200, “Concrete,” or as noted otherwise in the contract documents.

3. Construction

a. Concrete Encasement: When concrete encasement is shown in the contract documents, or when directed by the Engineer or Inspector, the trench shall be excavated and fine graded to a depth conforming to details and sections shown therein. The main shall be supported by precast concrete blocks of the same strength as the concrete for encasement and securely tied down to prevent floatation. Encasement shall then be placed to a depth and width conforming to the details and sections shown in the contract documents or per standard drawings.

b. Concrete Cradles: When concrete cradles are shown in the contract documents or when called for by the Engineer or Inspector, the trench shall be prepared and the main supported in the same manner as described in 1 above. Straps/Tie Downs shall be a minimum of No. 4 diameter rebar.

c. Concrete Saddles: When shown in the contract documents or when directed by the Engineer or Inspector, the main to receive concrete saddles shall be backfilled in accordance with Section 120, "Trench Excavation & Backfill" to the spring line and concrete placed for a depth and width conforming to details and sections shown in the contract documents.

d. Concrete Collars: When shown in the contract documents or when directed by the Engineer or Inspector, concrete collars shall be constructed in accordance with details and sections shown in the contract documents.

4. Measurement

Concrete Encasement, Cradles, Saddles, and Collars will be measured by the cubic yard of accepted work, complete in place. Reinforcing, if required by the Engineer or Inspector, shall not be measured for payment.

5. Payment

Concrete Encasement, Cradles, Saddles and Collars will be paid for at the unit price bid per cubic yard, which price shall be full compensation for furnishing and placing all materials, manipulation, labor, tools, equipment and incidentals necessary to complete the work. Payment for concrete encasement shall consist of 6 inches of concrete around the pipe where required (as per Standard Details), minus manholes, structures, etc.

220 - Concrete Vaults

1. Description

Reinforced concrete vaults shall be cast-in-place and shall include reinforcing steel, forms, finishing, curing, and all other appurtenant work required to provide a complete and functional structure.

All cast-in-place concrete shall be accurately formed and properly placed and finished as shown in the contract documents.

The Contractor shall inform the Engineer at least 24 hours in advance, of time and location at which he/she intends to place concrete in order for inspection of forms, reinforcing steel placement, and other preparatory work.

Precast vaults conforming to the Standard Drawings and Specifications shall be acceptable as a substitute to the cast-in-place vaults or as approved by the Engineer.

2. Materials

Concrete used shall be transit mix and shall have a 28-day compressive strength of 3,000 psi with a maximum slump of 6 inches and a minimum slump of 3 inches. The use of admixtures shall not be permitted unless approved by the Engineer. Cement shall conform to the general requirements contained in Section 200 - Concrete and the latest provision of ASTM Specifications C150 and C156 or most applicable approved equal provision.

3. Construction

a. **Forms:** Forms shall be designed to produce hardened concrete having the shape, lines, and dimensions shown in the contract documents.

   Surfaces which will be exposed to view when construction is completed shall be prefabricated plywood panel forms, job-built plywood forms, or forms that are lined with plywood or fiberboard. The forms shall produce finished surfaces that are free from off-sets, ridges, waves, and concave or convex areas.

   Plywood or lined forms will not be required for surfaces which are normally submerged or not ordinarily exposed to view. Other types of forms, such as steel or unlined wooden forms, may be used for surfaces which are not restricted to plywood or lined forms and may be used as backing for form linings.

   Before concrete is placed, a film of light form oil shall be applied to the forms.

   Forms shall be substantial and sufficiently tight to prevent leakage of mortar. Forms shall be thoroughly cleaned, braced, or tied to maintain the desired position, shape, and alignment during and after concrete placement.

   Form ties shall be corrosion resistant and shall have sufficient strength and rigidity to support and maintain the form in proper position and alignment.

b. **Form Removal:** Forms shall be removed after 24 hours, provided that the exposed surfaces can be immediately and effectively sealed to prevent loss of moisture. Otherwise, the forms shall remain in place for 48 hours. Precautions shall be taken in form removal to avoid surface gouging, corner or edge breaking, and other damage to the concrete.

c. **Reinforcing Steel:** Reinforcing steel shall be accurately formed and shall be free from loose rust, scale, and contaminants which reduce bond. Unless otherwise shown in the contract

documents, bar reinforcement shall be deformed and conform to requirements of Section 200, Concrete.

d. **Reinforcing Steel Placement:** Reinforcing steel shall be accurately positioned on supports, spaces, hangers, or other reinforcements and shall be secured in place with wire ties or suitable clips. All bars shall be shop fabricated and bent cold.

e. **Concrete Placement:** Concrete shall be placed as nearly as practicable in its final position to avoid segregation due to re-handling. When the concrete pour has commenced, it shall be carried on as a continuous operation until the placing of the panel or section is completed as a whole. All concrete shall be thoroughly compacted by suitable means during pouring operations and shall be thoroughly worked around reinforcement bars and into the corners of the forms. Mechanical vibration or other acceptable means shall be used to completely embed the reinforcement and eliminate honeycomb. Finished surfaces shall be brought to proper grade, struck off, and completed in a workmanlike manner. No honeycombing, rough spots or protruding stones shall be left exposed.

f. **Curing:** Concrete shall be protected from loss of moisture for at least 7 days after placement. Curing of concrete shall be by methods which will keep the concrete surfaces adequately wet during the specified curing period.

   i. Water Curing: Water saturation of concrete surfaces shall begin as quickly as possible after the initial set of the concrete. The rate of water application shall be regulated to provide complete surface coverage with a minimum of runoff.

   ii. Membrane Curing: Chlorinated, rubber-type, membrane curing compound may be used in lieu of water curing on concrete which will not be covered later with mortar or additional concrete.

   iii. Membrane curing compound shall be spray applied at coverage of not more than 300 square feet per gallon. If forms are removed before the end of the specified curing period, curing compound shall be immediately applied to the formed surfaces before they dry out. Curing compound shall be suitably protected against abrasion during the curing period.

g. **Finishing Surfaces:** Fins and other surface projections shall be removed from all formed surfaces. All exposed exterior surfaces shall have a rubbed finish. The floor surface shall be brush finished, unless otherwise specified.

h. **Repairing Defective Concrete:** Defects in formed concrete surfaces shall be repaired to the satisfaction of the Engineer within 24 hours, and defective concrete shall be replaced within 48 hours after the forms have been removed. All concrete which is honeycombed or otherwise defective shall be cut out and removed to sound concrete with edges square cut to avoid feathering.

   Concrete repair work shall be performed in a manner that will not interfere with thorough curing of surrounding concrete. Repair work shall be adequately cured.

i. **Painting:** All exposed metallic surfaces such as the cover plate, hinges, handles, and other exposed hardware, shall be primed and painted with one coat of primer and one coat of aluminum paint of approved and compatible quality.

j. **Backfill:** The Contractor shall cover the openings at each end of the vault with ¼ inch plywood placed outside the vault. Selected backfill (consisting of job excavated materials, finely divided and free from debris, organic material and stones larger than two inches in greatest dimension)

shall be placed in uniform layers not exceeding eight inches in un-compacted thickness and shall be carefully compacted around the sides of the vault until level with the surrounding ground.

4. Measurement

Reinforced concrete vaults shall be measured by the unit of the various sizes.

5. Payment

Payment for reinforced concrete vaults will be made at the unit price for each size vault installed.

Specifications 300 – 399: Water

300 - Water General

This section presents the criteria, standards and regulations related to the design of water distribution systems for general development service within the City of Copperas Cove water service area.

Designs for water system construction and improvements shall conform to the most recent edition of Rules and Regulations for Public Water Systems as published by the Texas Commission on Environmental Quality (TCEQ).

Waterline Designations are as follows:

a. Transmission water lines are generally lines conveying water from pumping facilities to reservoirs or lines conveying water directly between pumping facilities or directly between reservoirs. Such lines may not be tapped for any purpose without special approval.
b. Distribution water lines are generally lines providing local distribution of water and from which individual user service taps are made. Distribution lines stem from transmission lines or from other local distribution lines.
c. Service water lines are lines providing service from the distribution line directly to the individual's meter.

310 - Water Main Pipe

1. Description

This item shall govern the installation and material for water main pipe.

2. Pipe Material

a. General

Pipe materials other than those identified in this section may be proposed, but shall meet appropriate American Water Works Association Standards (AWWA) and bear the National Science Foundation (NSF) approval for use in potable water systems. Acceptance of alternative pipe material is subject to Public Works Director and City Engineer approval.

The following table summarizes the acceptable pipe materials and their uses:

Table 310.1

Pipe Material	Use	Pipe Size	Classification
Copper Tubing	Service lines	< 2”	Type K
Polyethylene	Service lines	< 2”	SDR 9 – 200psi
PVC	Service lines	2” – 3”	Schedule 80
PVC	Distribution, service lines	4” – 12”	C900 DR 18
Ductile Iron	Fire hydrant lead, distribution	6”	C151 Cl 350
Ductile Iron	Distribution line	8” – 12”	C151 Cl 350
Ductile Iron	Transmission line	16” – 60”	C151 Cl 250
Concrete Steel Cylinder	Transmission line	16” – 60”	C301
PVC	Transmission line	14” – 42”	C905 DR 18

b. Copper Tubing

Copper Tubing shall be of the type commercially known as type “K” soft and shall conform to NSF standard 61, ASTM B-88, or latest revisions thereof.

c. Polyethylene

Polyethylene shall be High Density Polyethylene shall be manufactured in accordance with ASTM F714 and ASTM D3035, and shall be of the material designation PE3408.

Both Fittings and pipe shall carry the same pressure rating. Piping shall have a 200-psi rating (SDR 9).

d. PVC

For Pipe 4” through 12”:

Dimensions, tolerances, and markings shall be in conformance with AWWA C900 (or latest revision thereof).

All pipes shall be Class 150 (DR 18).

Gaskets shall be designed with a retainer ring that shall be installed at the manufacturer. Gasket shall be in conformance with ASTM F477.

Approved Manufacturers: PW Eagle, J-M Manufacturing, Certainteed Corporation, Diamond Plastics, North American Pipe, Vinyltech, JM Eagle, Northern Pipe Products, Underground Solutions, Pipelife Jet Stream.

For Pipe 16” through 42”:

Dimensions, tolerances, and markings shall be in conformance with AWWA C905 (or latest revision thereof).

All pipes shall have a pressure rating of 235 PSI (DR 18) or have the highest pressure rating available for each size of pipe.

Gaskets shall be designed with a retainer ring that shall be installed at the manufacturer. The dimensions and design of the gasket shall meet requirements provided in ASTM D3919 and ASTM D2122. Gasket shall also be in conformance with ASTM F477.

Approved Manufacturers: Diamond Plastics, North American Pipe, JM Eagle, Northern Pipe Products.

e. Ductile Iron

Dimensions, tolerances, and markings for each nominal pipe size shall be in accordance with AWWA Standard C151 (or latest revision thereof).

All pipes shall be lined with cement mortar in accordance with AWWA C104 (or latest revision thereof).

Exterior coating shall consist of asphaltic material applied in accordance with AWWA Standard C151 (or latest revision thereof).

Rubber gaskets shall conform with AWWA Standard C111 (or latest revision thereof).

Approved Manufacturers: American, Griffin, US Pipe Company, Clow Water Systems, Pacific States, McWane.

All ductile iron pipe shall be wrapped with a minimum 8-mil thick polyethylene film conforming to AWWA C105 (or latest revision thereof). In highly corrosive soils, ductile iron pipe shall be double wrapped.

f. Concrete Steel Cylinder

Dimensions, material, manufacture, tolerances, and testing for each nominal pipe size shall be in accordance with AWWA Standard C301 (or latest revision thereof).

All pipe shall be AWA class 150 and shall be designed for an internal working pressure of 150 psi and minimum external load equivalent to 6 feet of earth cover. Pipe to be subjected to deeper bury, the pipe design shall be suitable for the earth loads indicated.

Each joint of pipe shall be furnished with a rubber gasket and a 12” diaper.

3. Construction

a. Embedment and Depth of Cover

Embedment material for water system construction shall conform to the City's standard details and the pipe manufacturer's recommendations, whichever is more conservative. The depth of cover to the top of the pipe shall be a minimum of three (3) feet below natural ground or the bottom of the flex base course where under pavement. If three (3) feet of cover is not achievable, a 2000 psi concrete trench cap at least 6 inches extending laterally 6 inches on both sides of the pipe zone onto undisturbed soil shall be installed. In rural areas and for pipes 16 inches in diameter and larger, the minimum depth of cover to the top of the pipe shall be four (4) feet. In no case will a minimum depth of cover of less than two (2) feet be allowed.

b. Testing

Testing of water utility improvements shall be in accordance with those procedures and standards required per TCEQ and the AWWA specifications. Refer to AWWA C605 "Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings" or AWWA C600 "Installation of Ductile Iron Water Mains and Their Appurtenances", or latest revisions thereof. All utility lines are to be hydrostatically tested at 150 psi for four hours. After the initial testing, any required repairs shall be completed and the repaired lines shall be tested at 150 psi for four hours. Leakage testing shall be performed in A State licensed/certified back flow prevention assembly tester must inspect all backflow prevention devices and the results shall be submitted to the City.

c. Disinfection

All water lines installed will be disinfected in accordance with TCEQ and AWWA standards, AWWA C651 "Disinfection Water Mains", or latest revision thereof, and witnessed by the City. Before final acceptance, the developer will provide the City with the test results after disinfection.

After disinfection, the developer will flush the system and refill with potable water and contact the City to schedule sampling for bacteria and chlorine residual testing. A sample will be taken for every 1,000 feet of waterline. The developer will repeat the disinfection and will be responsible for the cost of the bacterial sampling until bacterial limits are met. Only after the bacterial results are acceptable will the City accept the water line.

4. Measurement

Water main shall be measured horizontally per the linear foot installed.

5. Payment

Payment for water pipe shall be made at the contract unit price per linear foot complete in place. Said price shall be full compensation for furnishing all materials, including pipe, joint restraints, bedding, and thrust blocking, labor and equipment including excavation, bedding, and backfill, tools and incidentals necessary to complete the work.

311 - Water Main Fittings

1. Fittings

When Ductile Iron or PVC pipe is used, the fittings for distribution and transmission mains shall be Ductile Iron, in conformance with AWWA C110. The pressure class shall be the same as the pipe with a minimum of Class 250. Concrete Steel Cylinder (CSC) fittings shall be allowed when CSC pipe is utilized. All fittings shall have either mechanical or flanged joints.

Where required by site constraints, a ring connection may be used with prior approval from the City Engineering Department to connect the water main to another main running perpendicular to the water main. The minimum diameter of the ring connection shall be the diameter of the smaller main. If tees are used to connect the two lines, a gate valve shall be installed on the ring. If a tapping sleeve and valve is used, a gate valve is not required. The 90° bend may be rotated up or down as necessary to connect with the other main. Ebba MegaLug retainer glands shall be used at the connection of the 90° bend to the straight pipes on each side.

2. Valves

a. Valve Boxes

Cast iron valve boxes and covers shall be standard three (3) piece box and cover, consisting of base housing, extension hollow shaft and cover. The covers shall have the word “WATER” cast in raised letters in its upper surface on water mains and shall have no designation for other types of mains. Boxes furnished shall be adjustable unless shown otherwise on the plans and the extension hollow shaft shall be of sufficient diameter to admit readily standard valve wrench. Boxes shall be as manufactured by Mueller, Clow, East Jordan Ironworks, or pre-approved equal, and standard length shall be 24”-36” adjustable valve box unless pre-approved. Valve boxes will be required for every subsurface gate valve unless otherwise specified.

The valve box shall have a concrete slab around the valve box. In developed or paved areas, the slab shall be eighteen inches by eighteen inches, six inches thick. In rural or unpaved areas, the slab shall be thirty-six inches by thirty-six inches, six inches thick. The slab shall have a broom finish and shall be placed to grade. The reinforcement in the concrete slab shall be made of #4 rebar, and shall be arranged as shown in the standard details.

If a valve box extension is required, it shall be made of a two inch by two-inch, quarter inch thick steel tubing extension on the valve nuts for depths deeper than five feet. The steel tubing shall be attached to the valve nut with a quarter inch fillet weld. A quarter inch thick steel support plate shall be fillet welded to the top and bottom of the nut on the top of the extension. The maximum distance between grade and the top of the extension shall be two feet.

b. Isolation Valve Types

Valves on six (6) inch to sixteen (16) inch lines shall be of the resilient "wedge" or "seated" type, in conformance with AWWA C509. Valves on mains larger than 16 inches shall be rubber-seated butterfly valves in conformance with AWWA C504. Butterfly valves on lines 24 inches and larger must be placed in a vault, direct bury of these valves is not acceptable.

c. Air Release Valves

On transmission mains or pressure plane separation, air/vacuum release valves shall be located at all significant high points. A significant high point is defined where the crown of the pipe is

greater than 1.5 times the diameter of the pipe above the flowline of the pipe in the adjacent low points.

A combination air and vacuum release valve shall be used at each location where an air release valve is required. The riser or outlet of the air release valve shall be set two feet back from the curb and four feet above the ground level. A 180° fitting shall be installed so that the air or water will release downward. The vent to the atmosphere must be covered with 16-mesh non-corrosive screen. The outlet must be covered by an enclosure.

The air release valve can be enclosed in either a pre-cast manhole or a pre-approved traffic bearing enclosure.

All metal in the valves shall be stainless steel type 303, 304, or 316 and shall be in accordance with ASTM A240 or A276. Valve shall have a test pressure rating of 300 psi and a working pressure rating of 150 psi.

Acceptable manufacturers include: Apco Valve Company, Val-Matic Mfg. Co., Powerseal Corporation, and ARI Flow Control.

3. Measurement

Valves shall be measured on the basis of one complete in place in accordance with the details, drawings, and specifications.

4. Payment

Payment for fittings shall be made at the contract price per each complete in place. Said price shall be full compensation for furnishing all materials, labor, equipment, tools and incidentals necessary to complete the work on the basis of one complete in place in accordance with the details, drawings, and specifications.

Payment for valves shall be made at the contract price per each complete in place. Said price shall be full compensation for furnishing all materials, labor, equipment, tools and incidentals necessary to complete the work on the basis of one complete in place in accordance with the details, drawings, and specifications.

312 - Water Main Thrust Restraints

1. Description

This item shall govern the thrust restraint requirements for water mains.

2. Requirements

a. Underwriter Laboratories and Factory Mutual certifications are required on all restraint systems.
b. Restraint systems for PVC to meet or exceed ASTM F1674 (or latest revision thereof).
c. Restraint systems for Ductile Iron to meet or exceed UL Standard 194 (or latest revision thereof)
d. The designer is responsible for providing, on the construction drawings, an adequate restraining system design for the waterline, including minimum length of restrained pipe required in each direction. Computer programs as distributed by EBAA Iron, Inc. and Certain TEED are available to calculate restrained joint requirements.

3. Specific Requirements

a. Restrainer for Push-on type connections:

   The pipe shall be restrained by a split retainer band, meeting or exceeding ASTM A536-80, Grade 65-45-12. The restraint system may consist of two types: Two split retainer rings or for new construction use only one split and one solid cast backup ring.

   Bolts and nuts used to attach the split retainer ring shall comply with ANSI B 18.2, SAE Grade 5. Standard MJ Fitting Tee-bolts and nuts shall be fabricated from High Strength steel conforming to AWWA C11 and AWWA C153.

b. Compression Ring Fitting Restrainer:

   Compression ring with follower gland type of restrainer may be utilized in conjunction with Mechanical Joint (MJ) bell end ductile iron pipe fittings for restraining PVC C-900 and ductile iron pipe.

   Bolts and nuts used to attach the split retainer ring shall comply with ANSI B 18.2, SAE Grade 5. Standard MJ Fitting Tee-bolts and nuts shall be fabricated from High Strength steel conforming to AWWA C11 and AWWA C153.

4. Concrete Thrust Blocking

See Section 17.5-A.4.6 of the City Code of ordinances for requirements.

5. Payment

The payment for thrust restraints and/or thrust blocking shall be subsidiary to the water pipe cost. This shall include all work, material, labor, equipment, and appurtenances to install a complete and working thrust restraint system.

320 - Fire Hydrant Materials & Installation

1. Description

This item shall govern the materials and installation of Fire Hydrant assemblies.

2. Materials

Fire Hydrants shall be either Mueller Super Centurion, Clow Medallion, AFC American Darling B84B, or preapproved equal. Hydrants shall conform to the design requirements of AWWA C502.

Hydrants shall have a dry barrel and a six (6) inch inlet with a five and one-quarter (5 ¼) inch main valve opening, with one (1) pumper connection with a nominal inside diameter of 4 inches and two (2) hose nozzles with a nominal inside diameter of 2 ½ inches, and shall conform to the requirements of AWWA Specification C502 except that the barrels shall have a frangible section at the ground level for break off upon impact.

Hydrants shall open by turning counterclockwise.

Barrels shall be for thirty-six (36) inch bury. Extensions shall be provided where necessary to attain the proper height setting of hydrants. The inlet shall be a mechanical joint.

3. Construction

a. Setting Fire Hydrants

The hydrant shall be set truly vertical and be securely braced and blocked with concrete. It shall be set on a block of concrete at least one (1) foot square and six (6) inches thick placed on well compacted or undisturbed soil surrounded by a minimum of 4 cubic yards of clean gravel or stone to permit free draining of the hydrant.

The six (6) inch fire hydrant lead shall be of such length as is necessary to reach from the main to the hydrant location, and at such depth as to permit the pipe being installed in a horizontal position, and the barrel of the fire hydrant being in a vertical position. The bury depth may vary, and care must be taken to select and install the proper length of fire hydrant extension as required. All fittings on fire hydrant lead need to be restrained at the joints. Extensions will not be allowed.

A six (6) inch gate valve shall be installed on the six (6) inch hydrant lead between the fire hydrant and the main where shown on the plans.

Fire Hydrant shall be installed such that the final height above finished ground will allow the spanner wrench to remove the caps without repositioning.

b. Spacing

For residential zoned property or use, and as the property develops, fire hydrants shall be located at a maximum spacing of six hundred (600) feet as measured along the length of the roadway. No part of a residential structure shall be farther than five hundred (500) feet from the fire hydrant as measured by the route that a fire hose would be laid.

For non-residential zoned property or use, and as the property develops, fire hydrants shall be located at a maximum spacing of three hundred (300) feet as measured along the length of the roadway. No part of a non-residential structure shall be farther than five hundred (500) feet from the fire hydrant as measured by the route that a fire hose is laid.

Drain hydrants shall be located at all low points on transmission lines. Fire hydrants shall be located within the distances from public streets as shown in the Standard Details.

c. Cul-de-Sacs

If a fire hydrant is not required in a cul-de-sac due to distance requirements as outlined in the subdivision ordinances, a 2-inch blow off valve should be located behind the curb at the end of the line and in such a manner to allow drainage to an appropriate location.

The flushing device shall be a Kupferle 9400WC or approved equal. The fittings between the water main and the flushing device shall be copper compression fittings. A meter shall be installed between the main and the flushing device, and the meter shall be installed in a standard meter box. Erosion control and area drainage measures at the blow off discharge point must be installed to meet site drainage conditions. Also, the discharge of chlorinated water must comply with TCEQ requirements.

4. Measurements

This item shall be measured by each fire hydrant assembly installed.

5. Payment

The Payment for fire hydrants shall be made at the contract price per each complete in place. Said price shall be full compensation for furnishing all materials, labor, equipment, tools and incidentals necessary to complete the work on the basis of one complete in place in accordance with the details, drawings, and specifications.

330 - Water Service Connections

1. Description

This item shall govern the material and installation of water service connections.

2. Materials

a. Service Lines

The developer's engineer shall determine service line sizes for multi-family, commercial, or fire lines. The pipe material for these services shall be in accordance with section 310 “Water Main Pipe”.

b. Tapping Sleeves and Saddles

All tapping sleeves and saddles shall be constructed of stainless steel. Double strapped saddles shall be acceptable for taps less than four (4) inches. Taps greater than or equal to four (4) inches shall require full tapping sleeves. Requests for size on size taps with the use of a full tapping sleeve may be approved upon review by the Director of Public Works and/or City Engineer.

Approved tapping saddles include Mueller galvanized or cadmium coated, Smith-Blair #313 (formerly Rockwell) or Ford F202 service saddle for connections to cast iron or ductile iron pipe. Connections to a PVC water main shall be made with a Smith-Blair #317 service saddle.

c. Valves on Service Lines

Connections that are greater than two (2) inches shall require resilient seated or wedge type gate valves. Corporation stops are only acceptable on taps two (2) inches or smaller. This would include taps made for air release valves.

Corporation Cocks shall be Mueller H-15008, or Ford equal, which can be either CC or IP thread x compression outlet. Curb and meter stops for service connections shall be as follows: For single service connections, curb stops shall be Mueller H-14258, or Ford equal, a compression inlet with lockwing head, or a place to lock a padlock when isolating the line for service. For double service connections, “U” branch connections shall be Mueller H-15363 or Ford equal with a compression inlet. Two (2) curb stops, Mueller H-14265 shall be furnished and installed with lockwing head, or a place to lock a padlock when isolating the line for service.

d. Backflow Prevention & Pressure Reducing Valves

Backflow Prevention and Pressure Reducing Valves shall be installed in accordance with City of Copperas Cove Plumbing requirements.

e. Meter Boxes

Meter boxes may be of plastic construction when located in non-traffic areas. Steel meter boxes are required when the meter box is located in traffic areas. Owner shall install 3” meter in a concrete vault (with spring assisted lid) with appropriately sized bypass. The meter shall be located as close the main as possible, with a minimum two-foot clearance. The meter locations should be reviewed by the city inspector, and variations may be approved on a case by case basis only. Meter vaults shall be installed flush with the surrounding ground in traffic areas (vehicle and pedestrian traffic), and vaults shall be 6” above the surrounding ground for non-traffic areas.

f. Leak Detector Double Check Assembly

All new fire line services and those encountered in a construction project shall have a leak detector double check valve with a detection meter installed. The detector shall be installed in a concrete vault, and where possible, the vault shall be installed in the right of way. In commercial applications, vaults may be installed inside the building. The vault shall be manufactured by Concrete Products, Inc. or approved equal, and the door shall be spring assisted. The detector check valves must be a minimum of six inches above the floor. All test ports shall have protective caps. Upon installation, the assembly must be tested by a certified tester, and the results must be furnished to the City of Copperas Cove, Water Billing Office. Test results must be furnished to the City by the owner on an annual basis.

3. Measurement

Water service connections shall be measured on the basis of one complete in place in accordance with the details, drawings, and specifications.

4. Payment

The Payment for water service connections shall be made at the contract price per each complete in place. Said price shall be full compensation for furnishing all materials, labor, equipment, tools and incidentals necessary to complete the work on the basis of one complete in place in accordance with the details, drawings, and specifications.

340 - Blow-off Assembly

1. **Description**
   This item shall consist of blow-off assemblies installed in accordance with these specifications and as directed by the Engineer.

2. **Materials**
   The materials for blow-off assemblies, installation and adjustment shall conform to the specifications.

3. **Construction**
   Blow-off assemblies shall be installed where shown on the plans and/or at locations designated by the Engineer/Owner and at the end of all dead-end mains in accordance with the Texas Administrative Code (TAC) rules to include 30 TAC § 290.44.(d)(5), (6), or latest revision thereof. All blow-off assemblies shall be joint restrained based on pressure requirements (minimally from the water main to the end of the blow off).

   The blow-off assembly shall consist of the following: all galvanized iron pipe, valve, and fittings of the various sizes shown on the plans, 6-inch valve box assembly and concrete collar around the valve box. Valve box shall be raised or installed to finished grade and installed in accordance with City Standard Details.

4. **Measurement**
   Blow-off assemblies will be measured by the unit of each such assembly of the various sizes of blow-offs installed.

5. **Payment**
   Payment for blow-off assemblies will be made at the unit price bid for each such assembly of the various types and sizes installed in accordance with the details shown in the Standard Details. Such payment shall also include excavation, selected embedment material, anticorrosion embedment when specified, and the hauling and disposition of surplus excavated materials.

Specifications 400-499: Sanitary Sewer

400 - Sanitary Sewer General

This section presents criteria, standards and regulations related to the design of wastewater collection system facilities for general development within the City of Copperas Cove wastewater service area. The material is directed to the competent design professional and is not intended as a detailed design handbook or technical specifications.

Designs for wastewater system construction and improvements shall conform to the requirements of the Texas Commission on Environmental Quality (TCEQ). Designs for all public improvements shall conform to the Revised Subdivision Ordinance design guidelines.

410 - Manholes

1. Description

This item shall govern the installation and materials for manholes.

2. Materials

Manhole construction shall be pre-cast concrete or cast-in-place concrete. Fiberglass manholes may be used only in locations approved by the City. Manholes shall have resilient watertight pipe connections. The manhole base shall have a "U"-shaped channel to provide for a smooth flow of water and to carry the pipe slope through the manhole. The manhole invert depth shall be per the requirements of TCEQ 217. For connecting pipes of the same size, an invert drop of 0.1-ft. across the manhole is required. Connecting pipes of different size should have a crown elevation match. In situations where conservation of available head is critical for pipeline design, a waiver from these requirements may be granted to allow pipe invert elevations that provide an energy grade line match, as supported by calculations using the sizes, slopes, and design flows for the connecting pipes.

a. Pre-cast Manholes

Pre-cast Concrete manholes shall consist of precast riser, concentric cones, and grade rings supported on a cast-in-place concrete base. For water containment construction, precast reinforced concrete manhole sections shall be of the bell and spigot or tongue and groove design meeting the requirements of ASTM C-478, having a wall thickness equal to that of ASTM C-76 wall “B”, using a trapped type preformed O-Ring rubber gasket conforming to the requirements of ASTM C-443. Risers shall be in standard lengths of one (1) through six (6) feet in increments of one (1) foot. Manhole connector shall be flexible seal boot resilient connector meeting the requirements of ASTM C-923. Pre-cast manholes shall be placed on a bedding six (6) inches minimum think composed of 3/8”-1” crushed rock.

b. Cast-in-Place Manholes

Cast in place manholes will require a sealed design submitted by the contractor and approved by the city engineer.

c. Frame and Cover

Manhole frame and cover shall be Neenah Foundry, East Jordan Ironworks, or approved equivalent. Frame and cover shall meet the requirements of TCEQ. Covers shall be provided with pick slots. The word “Sewer” shall be cast in each cover. Watertight and airtight manhole ring and cover shall be used for a manhole in the 100-yr flood plain, and anywhere else required by the TCEQ.

d. Manholes inside a Roadway

Manholes inside a roadway shall have a flat lid, and the manhole shall be surrounded by a five foot by five-foot, six-inch thick minimum concrete collar. The collar should have two points in direction of traffic flow, a diamond configuration. The reinforcement for the collar shall be one #4 rebar, parallel to each side and two inches above the bottom of the section. The rim elevation of the manhole shall be within one inch of the roadway elevation. This can be accomplished by using one-inch grade rings.

e. Manholes in Undeveloped Areas

A manhole in an undeveloped area shall extend six (6) to twelve (12) inches above the surrounding grade, so that they will be visible and less likely to flood.

f. Drop Manholes

A drop manhole is required by the TCEQ when the upstream pipe is a specified height above the manhole invert. Please reference TCEQ 217, or latest revision thereof, for the height when a drop manhole is required. The drop pipe must be outside the manhole. Where the difference in elevation between the incoming sewer and the manhole invert is less than 24 inches, the invert should be filleted to prevent solids deposition.

g. Installation of manhole around existing sewer pipe (doghouse manhole)

Should a manhole need to be installed around an existing sewer, the existing sewer pipe must first be exposed and an invert constructed under the pipe. The excavation must be kept free of water while the manhole is being constructed. Inverts may be formed by pouring the concrete invert (3,000 psi) and cutting out the top half of the pipe. A precast manhole section, with U-shaped cutouts for the pipe, can then be installed over the existing pipe. The voids of the cutout must then be filled with hydraulic cement. The top sections of the manhole shall be constructed per the standard manhole specification. Cast-in-place manholes will also be permitted for installation around existing sewers. The sanitary sewer pipe shall not protrude into the trough of the manhole (all pipe shall be flush with the manhole).

h. Manhole Testing

Testing of sewer manholes shall be in accordance with TCEQ requirements.

i. Manhole Lining

Manholes will be lined, at the termination points of force mains and at locations required by the City, in accordance with City specifications for protective coatings.

3. Measurement

a. Manholes shall be measured by each complete installation in place.

4. Payment

a. Manholes shall be paid by each complete installation in place. This includes excavation, backfill, compaction, concrete collar (if manhole is in the street), boot seals, watertight pipeline connections, labor, tools and equipment to install a complete and working manhole.

411 - Sanitary Sewer Gravity Pipe

1. Description

This item shall govern the materials and installation of sanitary sewer gravity pipe.

2. Materials

The material of construction for gravity sewer pipe sizes 4 inches through 15 inches shall be SDR 26 PVC and ASTM F679 (PS 115) for sizes 18 inches through 27 inches. This pipe is intended for gravity manhole to manhole connections.

PVC sewer pipe and fittings shall conform to the requirements of current ASTM Specification D-3034-SDR 26, and shall be equipped with joints meeting the requirements of current ASTM Specification D-3212.

3. Construction

a. Regulatory Requirements

All sanitary sewer installations shall be in conformance with TCEQ's Design Criteria for Sewerage Systems (30 TAC 217 or latest revision thereof).

b. Embedment and Depth of Cover

Embedment material shall conform to the City's standard details and the pipe manufacturer's recommendations, whichever is more conservative. The depth of cover to the top of the pipe shall be a minimum of three and a half (3.5) feet below natural ground or the bottom of the flex base course where under pavement. If three and a half (3.5) feet of cover is not achievable, a 2000 psi concrete trench cap at least 6 inches extending laterally 6 inches on both sides of the pipe zone onto undisturbed soil shall be installed. In rural areas and for pipes 16 inches in diameter and larger, the minimum depth of cover to the top of the pipe shall be four (4) feet. In no case will a minimum depth of cover of less than two (2) feet be allowed.

c. Testing

Testing shall be in accordance with those procedures and standards required per TCEQ and the AWWA specifications.

4. Measurement

Sanitary sewer pipe shall be measured horizontally per the linear foot installed from center of manhole to center of manhole.

5. Payment

Payment for sanitary sewer pipe shall be made at the contract unit price per linear foot complete in place. Said price shall be full compensation for furnishing all materials, including pipe, bedding, and labor and equipment including excavation, bedding, and backfill, tools and incidentals necessary to complete the work.

412 - Sanitary Sewer Force Main

1. Description

This item shall govern the installation and material for water main pipe.

2. Pipe Material

All pipe, fittings, and joints shall meet or exceed the requirements of ASTM D2241, with the exception that solvent cement joints shall not be used. The pressure rating, size, and pressure class shall be included as part of the design drawings or documents.

Pipe shall have an integral bell and gasket seal with the locked-in type gasket conforming with ASTM F477.

Pipe joints shall also conform to ASTM D3139.

Pipe materials other than those identified in this section may be proposed, but shall meet appropriate pressure requirements and corrosion resistance for sanitary sewer force mains. Acceptance of alternative pipe material is subject to Public Works Director and City Engineer approval.

3. Construction

a. Embedment and Depth of Cover

Embedment material for shall conform to the City's standard details and the pipe manufacturer's recommendations, whichever is more conservative. The depth of cover to the top of the pipe shall be a minimum of three and a half feet below natural ground or the bottom of the flex base course where under pavement. If three and a half (3.5) feet of cover is not achievable, a 2000 psi concrete trench cap at least 6 inches extending laterally 6 inches on both sides of the pipe zone onto undisturbed soil shall be installed. In rural areas and for pipes 16 inches in diameter and larger, the minimum depth of cover to the top of the pipe shall be four (4) feet. In no case will a minimum depth of cover of less than two (2) feet be allowed.

b. Testing

Testing shall be in accordance with those procedures and standards required per TCEQ.

4. Measurement

Force Main pipe shall be measured horizontally per the linear foot installed from center of manhole to center of manhole or end of main.

5. Payment

Payment for force main pipe shall be made at the contract unit price per linear foot complete in place. Said price shall be full compensation for furnishing all materials, including pipe, joint restraints, bedding, and thrust blocking, labor and equipment including excavation, bedding, and backfill, tools and incidentals necessary to complete the work.

420 - Laterals

1. **Description**
   This item shall govern the installation and materials for sanitary sewer service laterals.

2. **Materials**
   Service line connections to proposed mains shall be made with wye fittings. Service line taps to existing mains shall be made using a saddle type connection designed to join the types of pipe that are to be connected. Service taps shall be watertight and shall not protrude into the sewer main. Service line taps shall be made on the top half of the main line, and the bottom lip of the connecting pipe shall not dip below the centerline of the main.

3. **Construction**
   All lateral installations shall be in accordance with these specifications and TCEQ requirements. For sanitary sewer mains that are 12 inches in diameter and smaller, all laterals shall be individually connected using the appropriate size wye placed in line with the main line.

   The minimum slope allowed for service lines is 1.0% (1/8-inch per linear foot). Grade breaks should be made with standard fittings and not exceed 45 degrees. Minimum service line depth of cover at the curb line is 36 inches. Service lines shall extend from the sanitary sewer lateral in the street to a point at least two (2) feet behind the curb, unless otherwise shown.

4. **Measurement**
   Laterals shall be measured by each complete installation.

5. **Payment**
   Payment for laterals shall be made at the contract unit price for each installation complete in place. Said price shall be full compensation for furnishing all materials, including pipe, labor and equipment including excavation, bedding, and backfill, tools and incidentals necessary to complete the work.

450 - Bypass Pumping

1. Description

The work covered by this item consists of bypass pumping operations for existing sanitary sewers less than 24-inches in diameter in order to temporarily reroute sanitary sewer flows to prevent a sanitary sewage overflow (SSO) and to provide adequate and reliable sanitary sewer flow at all times during construction.

The Contractor shall be responsible for the design of the bypass pumping plan and system. Contractor's bypass pumping system design shall be developed based upon the requirements of the Contract Documents.

The bypass system shall meet the requirements of all codes and regulatory agencies having jurisdiction.

Pump and haul bypass systems shall not be allowed for larger sanitary sewers with significant sewage bypass flows. Contractor shall provide for temporary measures to convey sewage flows and avoid sewage spills should a storm event occur that generates sanitary sewer flows in excess of Contractor's bypass pumping system.

2. Submittals

a. All submittals shall be in accordance with Owner's requirements and shall be acknowledged by Owner prior to delivery.
b. For all projects requiring bypass pumping, the Contractor shall prepare and submit a Bypass Pumping Plan (BPP). The BPP shall be submitted a minimum of two weeks prior to commencing any portion of the proposed scope of work and shall be acknowledged by City prior to beginning Work. The BPP shall be signed and sealed by a professional engineer licensed in the State of Texas (Contractor's Engineer).
c. Contractor shall submit manufacturer's product data, instructions, recommendations, shop drawings, and necessary certifications in order for the proposed BPP to be reviewed and acknowledged.
d. The following shall be submitted as part of the BPP:
    i. A cover letter containing the following information;
        A. The project name and job number.
        B. The name and address of the Contractor.
        C. Contact information of the Contractor's project manager, superintendent, foreman/supervisor, safety professional, etc.
        D. A description and location of the planned bypass pumping work to be performed; include data for stationary and pump and haul bypass systems as applicable.
    ii. Emergency ("24/7") contact information for the bypass pumping subcontractor, if applicable. Make sure to include the name, cell phone number, and title of the person(s) onsite responsible for the bypass pumping operation.
    iii. The name, phone number, title, signature, and PE seal of the Contractor's Engineer preparing the BPP.
    iv. Copies of permits or other documents showing the Contractor has obtained all clearances necessary for installation and operation of the BPP.
    v. If Contractor elects to use a combination of stationary bypass pumping and pump and haul for his bypass system, Contractor's BPP shall identify the quantity of flows that will be

pumped and pumped and hauled for each type of bypass system along with the points where flows will be removed and reintroduced into the sanitary sewer system.

vi. A description of the maximum amount of sanitary sewer flows to be bypassed by the Contractor's bypass pumping system and how the flow conditions will be monitored during system operations (including all flow measurement devices, calculations, equipment, or other sources of how data was obtained). If the bypass plan is not based on the maximum wet weather flow in the sanitary sewer, this description must include an explanation for how the contractor plans to monitor the weather for potential flows exceeding his bypass system capacity and how he will avoid having to bypass during wet weather events exceeding his bypass system capacity.

vii. The date and time the bypass pumping is expected to begin and be completed. Indicate if bypass pumping will take place outside normal work hours which are between 8 am to 5 pm Mondays through Fridays (except for City observed holidays). Contractor shall reimburse City for the overtime costs required by his bypass pumping testing outside of City normal work hours.

viii. The pump curves, showing operating range. This shall include the proposed system curve, addressing the pump operation in relation to the suction/discharge piping's alignment with respect to restriction and/or elevations.

ix. Suction and discharge piping material(s) and capacity to be used for the bypass pumping operation, including the material(s) for any bend(s) and/or valve(s) that will be used.

x. A sketch showing the location of the pump(s) and the route of the suction, and discharge piping. If Contractor elects to use locations outside of the easements obtained by City, Contractor shall be solely responsible for obtaining the required easements and written documentation required for use of these locations. The sketch shall be dimensioned and all-inclusive showing all City manholes.

xi. A Traffic Control Plan that pertains solely to the bypass pumping operations.

xii. An Emergency Plan detailing procedure to be followed in the event any portion of the bypass operation fails and causes either surcharging or an actual SSO.

3. Equipment and Materials

The Contractor shall provide all necessary pumping equipment, piping and all other necessary appurtenances in order to maintain adequate and reliable sanitary sewer flow in the sanitary sewer system (including any temporary manholes) at all times during construction for stationary pumping and pump and haul bypass pumping systems. All materials, equipment, etc., must be in good condition, and should not have visible damage such as cracks, holes, foreign material, blisters, etc.

a. Plugs

Plugs must be selected and installed according to the size of the line to be plugged. Plugs shall be adequately secured and anchored to prevent plug movement or escape into the adjoining sanitary sewers should the plug fail.

b. Stationary Bypass Pumping Systems

i. High-Density Polyethylene (HDPE) is the preferred pipe material for all bypass piping. HDPE shall be used when bypass discharge pipe will be going through streams, storm water culverts, and/or environmentally sensitive areas. At other locations, flexible discharge hose that is in good condition and does not leak, may be allowed subject to it acceptably passing testing.

ii. HDPE pipe must be assembled and joined using couplings, flanges or fusion welding in order to avoid joint leakage.

iii. HDPE fusion welding must be performed by personnel certified as fusion technician(s) by the manufacturer of HDPE pipe and/or fusing equipment. City shall examine welds prior to use in BPP operation.
iv. BPP shall indicate the proposed DR of the pipe to be used.
v. Rigid suction hose that is in good condition and does not leak may be allowed for withdrawal of flows from the suction point into the bypass pumps.
vi. Pipe material other than HDPE shall be submitted to City for approval. Neither "Irrigation type" pipe nor glued PVC pipe will be permitted.
vii. Any hoses or pipes that leak shall be removed and replaced with non-leaking hoses or pipes.
viii. Pumps must be fully automatic self-priming units that do not require the use of foot valves or vacuum pumps to prime the system. Contractor shall provide suitable spill control and containment measures to avoid environmental contamination by pumps, fuels, or lubricants. All pumps shall be open impeller solids handling type pumps, capable of passing a minimum of 3-inch diameter solids. Contractor shall have one backup pump, equal in capacity to the largest pump in the system, connected into the bypass pumping system, and ready for operation in case any of the primary pumps fail. The backup pump shall not be used in Contractor's calculations for determining the pumping capacity requirements for the stated flow conditions above. Sound-attenuated pump enclosures shall be required on all projects where the bypass pumps are located within 50 feet of any residence, business, park, or other presence of people.

c. Pump and Haul Bypass Pumping Systems

Pump and haul bypass pumping systems shall use good-quality vacuum trucks, equipment, and materials from manufacturers commonly engaged in the manufacture, service, and repair of these types of sanitary sewer service trucks and equipment. All equipment shall be designed and manufactured for sanitary sewer service, shall function acceptably, be reliable, and free from leaks or other deleterious environmental impacts. All equipment proposed for use in pump and haul bypass pumping shall have been maintained per the manufacture's recommendations. Equipment service records shall be made available at City request. Any hoses or pipes that leak shall be removed and replaced with non-leaking hoses or pipes.

4. Construction

During construction, it will be the Contractor's responsibility to maintain a safe and secure environment at all times. All provisions and/or requirements of the BPP must be followed throughout the course of any bypass flow operations. Contractor must notify the City Inspections Department 72 hours prior to commencing the bypass pumping operations.

a. The Contractor shall have full time (24-hour), onsite qualified pump personnel including supervision for monitoring the entire bypass installation while it is in operation. The entire length of bypass piping shall be walked and inspected hourly to monitor for leaks. High-level alarm notification to cell phones shall not eliminate this requirement. Where bypass pumping systems exceed 1,500 feet in length or cannot be completely observed from the bypass pump location, at least one attendant shall be assigned to the pump operation, and one additional attendant shall be assigned to walk and monitor the pipeline.
b. Prior to installing any plugs, the Contractor and City shall inspect the existing pipe using a pole camera, for imperfections that might cause damage to the plug, cause the plug to not seal or function properly, or compromise the integrity of the pipe when the plug is inflated. The results

of this inspection shall directly impact the planned plugging location(s). Afford City an opportunity to confirm that the location of plug(s) is acceptable.

c. Lines inserted into any manholes or structures shall be constructed with elbows, or be otherwise angled, to direct discharge along the most efficient path for entry into the downstream line without causing unnecessary turbulence of flow. The termination point of the discharge piping shall extend to the crown of the pipe housed within the manhole or structure receiving the bypassed flows.
d. Contractor shall provide continuous supply on-site fuel storage sufficient for 24- hour operation of the bypass pumping installation.
e. Contractor shall protect all components of the bypass operations from vandalism and vehicular damage by making the site secure.
f. Contractor shall minimize sanitary sewer odors by using lids, shroud covers, or any method accepted by the Inspector or Engineer.
g. Contractor shall be solely responsible for any and all damages to private and/or public property caused by, or during, the installation, operation, and/or removal of the bypass pumping system. Contractor shall be fully responsible for all damages and costs related to the installation, operation, and maintenance of Contractor's bypass pumping operations including damages, clean up, fines, penalties, and other related costs.
h. Once all work is completed and the bypass pumping operation is no longer required, the Contractor must disinfect and drain the entire BPP system in accordance with approved submittal.
i. City will not be responsible for additional traffic control measures that might be required by TxDOT, or any other public entity having jurisdiction of the project location.
j. Plug Installation

5. Safety

a. The Contractor shall be solely responsible for the safe and effective use of plugs, including the proper combination of inflatable/mechanical plugs to block the sewer flow at both the upstream and downstream ends of a sewer bypass.
b. Inflatable plugs should be used only after receiving training as recommended by the manufacturer.
c. An inherent danger exists with all inflatable products. If any conditions with this equipment exist that may jeopardize the safety of workers or others corrective actions should be taken prior to the equipment use.

6. Plugs

a. Plugs must be selected and installed in accordance with the manufacturer's recommendations.
b. Plugs must also be selected and installed according to the size of the line to be plugged.
c. Spare plugs – Provide spare plugs on-site ready to be installed in the event a plug fails or becomes dislodged.
d. Plugs will be in good condition and reviewed by the Contractor for defects that might lead to failure prior to being installed. The Contractor shall sign the Plug Inspection form.
e. Plugs must be removed from the system upon completion of the work.
f. Damages – The Contractor will be responsible for damages due to plugs being left in place or dislodged, including but not limited to:

g. Damages to City infrastructure or private property.
h. Costs associated with sanitary sewer overflows including: regulatory fines; sewage and debris cleanup; debris disposal at an appropriate landfill; disinfection of all surfaces which have contacted the sewage.
i. Costs associated with locating and retrieving lost or dislodged plugs.

7. Testing and Quality Control

Testing and quality control will be required for stationary bypass pumping and pump and haul bypass systems as indicated below. Contractor shall obtain and keep copies of all required permits on site prior to beginning Testing and throughout performance of the Work.

Contractor must prove to the Owner that the equipment, materials and all operational aspects and/or appurtenances related to the BPP are in good condition prior to commencing the bypass pumping operation. Failure to do so will result in the Contractor not being permitted to continue with any construction work requiring bypass pumping operations. Contractor must notify the City Inspections Department 48 hours prior to commencing any testing. Any flows excessively surcharging the sanitary sewer system during the test and/or during actual bypass periods will deem the BPP to be unacceptable and must be revised and resubmitted for approval. There will be no separate pay item if this condition occurs during the timeframe in which bypass pumping test and/or operations are underway during the project. No testing of the bypass pumping operation shall be conducted between Thursday and Sunday, unless approved by City. If bypass pumping will take place outside normal work hours which are between 8 am to 5 pm Mondays through Fridays (except for City observed holidays), Contractor shall reimburse City for the overtime costs required by his bypass pumping testing outside of City normal work hours.

a. Stationary Bypass Pumping Systems

Discharge piping, joints and all accessories will be required to be hydrostatic tested. All piping, joints, and accessories shall be able to withstand at least twice the anticipated pressure or a minimum of 50 psi, whichever is greater.

For any bypass operations proposed a test run of at least 2 hours must be satisfactorily performed, prior to commencing any construction work. All testing shall be performed and approved by City. Contractor shall provide both a strobe light-type high-level alarm, as well as alarm notification to their cell phones, as well as other appointed personnel to be identified by City, and ensure adequate alarm notification is attained prior to actual startup of the test period.

During the testing period, the Contractor shall install a Float Monitoring System in the upstream manhole and/or pipe to confirm that the bypass pumping flow data shown in their BPP remains applicable. The float monitoring system shall remain in the manhole and/or pipe for the duration of the bypass operation. The data collected during the test and duration of the bypass operation shall be provided to City for evaluation and recording. It will be required of the Contractor to have personnel remain onsite at the flow monitoring system in order to continuously record (every 30 minutes) the flows during both the test and actual bypass pumping periods. Contractor shall submit a copy of Testing Float Monitoring System Data log to City upon successful completion of test. Data log shall be in column format with each line entry indicating the time, elapsed time of test, level of flow indicated in manholes, total flow being pumped by the BPP system, and any comments pertaining to the test.

b. Pump and Haul Bypass Pumping Systems

Contractor shall perform a full-scale demonstration test of his proposed pump and haul bypass system to prove that his system can be successfully used for bypass pumping at the proposed locations. Contractor's test shall use all of the equipment and staff that will operate the bypass pumping system during performance of the Work. Traffic control systems required during the Work shall be utilized during the test. Withdrawals and discharges of flow shall be from or into the manhole locations identified in the Contractor's BPP except for pump and haul system. This requirement is intended to demonstrate to City that the Contractor's proposed BPP is capable of providing satisfactory bypass pumping prior to Contractor beginning the Work, including the size and number of trucks and cycles times. Pump and haul system flow shall be disposed of in a TCEQ licensed facility and all manifests shall be kept and submitted to City. Disposal pump and haul flow in a nearby manhole is not acceptable.

c. Test Failure

Any failure of equipment, or activities associated with the bypass pumping operations contributing to either an excessive surcharge or SSO, shall be deemed a failed test. The test shall then be stopped and any necessary cleanup or reporting efforts performed. The BPP will need to be revised, resubmitted and acknowledged prior to the test initiating again. Any effort by City or other third parties to mitigate damages resulting from any surcharging or SSOs shall be the direct and sole responsibility of the Contractor. This includes any related fines, penalties, or damages to public or private property.

d. Plug Testing

Plugs shall be tested prior to use. The inflatable plug shall be placed inside of a structurally sound pipe or conduit and inflated to its operating pressure and monitored for 24 hours to observe it holds the required pressure. This testing shall be performed in accordance with the manufacturer's recommendations. Inflating a plug when it is not constrained or overinflating the plug creates a risk of being injured by pieces of the plug exploding if it fails.

8. Measurement and Payment

Measurement for the work specified herein will be by lump sum and as required by the contract documents. Payment of the "Lump Sum" bid for Bypass Pumping shall be in accordance with the following: Any effort required for multiple set-ups and operations shall be included in the lump sum price.

a. When initial set-up and operation of the bypass pumping system begins (including a successful test), 20% of the "Lump Sum" cost will be paid as applicable to the bypass system used; stationary bypass pumping or pump and haul bypass systems.
b. 60% of the "Lump Sum" cost will be paid over equal monthly payments (estimated from the BPP or other documentation approved by the Inspector) during the bypass pumping operation as applicable to the bypass system used; stationary bypass pumping or pump and haul bypass systems.
c. 20% of the remaining "Lump Sum" cost will be paid upon an acceptable removal and/or disassembly of all components of the BPP, including site cleanup as applicable to the bypass system used; stationary bypass pumping or pump and haul bypass systems.
d. For multi-bypass pumping setups, payment will be proportional to the overall amount of the established bid line item.

e. Measurement of the work for pipe plugs shall be incidental to the work and will not have a separate pay item.
f. Any damages, repairs, etc., to private or public property will not be considered for any additional payment.

460 - Abandonment of Existing Mains and Manholes

1. Description

This item shall govern the abandonment of sanitary sewer mains and manholes specified in the contract documents. The sanitary sewer facility shall be abandoned in accordance with the specifications outlined herein and in conformity with the limits shown in the contract documents.

Abandoning of sanitary sewer lines and manholes shall not occur until all existing sanitary sewer services have been transferred to another line and directed by the Inspector.

2. Materials

Materials for abandonment of sanitary sewer pipe and manholes.

A manhole shall be abandoned in accordance with the detail. All existing sewer lines into the manhole shall be plugged with flowable fill material. For a brick manhole, a height of a minimum of two feet shall be removed. In paved areas, the surface around the manhole shall be replaced to match the surrounding surface per the specification and standard details. In grass areas, three inches of flowable backfill material shall be installed over gravel. Then, the remaining area shall be filled up to the surface with a minimum of six inches of top soil.

Grout material or flowable fill shall meet requirements of section 213 “Flowable Fill.”

3. Construction

Abandonment of sanitary sewer lines shall be accomplished by installing a concrete plug at each manhole penetration. Concrete plug shall be of sufficient size to prevent the flow of infiltrated groundwater. The method shall adequately provide for the removal and legal disposal of existing sewer materials in the system.

Mains to be abandoned shall be grouted only if required by the contract documents and payment as per these specifications is provided.

The concrete structure of the manhole shall be removed to a depth of 2 feet under proposed subgrade or finished ground elevation. Manhole rings and covers shall be removed and delivered to the City storage site designated by the Inspector.

4. Measurement

Grouting of abandoned manholes shall be measured on the basis of each one complete in place.

5. Payment

Payment for abandonment of manholes will be on the basis of each one complete in place. Abandonment of the sewer lines shall be subsidiary to the manhole abandonment where the line plugs are installed prior to the manhole abandonment. Said price shall be full compensation for furnishing all materials, labor, equipment, tools and incidentals necessary to complete the work. Unless otherwise shown in the contract documents, abandonment/grouting of manholes will not be a separate pay item.

Specifications 500-599: Streets, Walks, Driveways

500 – Streets General

1. **Construction Tolerances**
   Maximum allowable deviations from alignments and grades shown on the plans shall be:

2. **Alignment**
   Variations from the true alignment shall not exceed zero point zero five (0.05) feet combined amount in any one hundred (100) foot distance.

3. **Grade**

   a. Subgrade: -/+ 0.05 feet
   b. Finished Base Course: -/+ 0.03 feet without abrupt changes
   c. Finished Pavement Surface: -/+ 0.02 feet
   d. Curbs: For grades of
      i. Over 1.0%- 0.02 ft
      ii. 0.5 to 1.0%- 0.01 ft
      iii. Under 0.5%- 0.00 ft

      Regardless of the allowable tolerances indicated for curbs, all curb and gutter shall be constructed to proper grade to drain freely and any gutter constructed with water pockets shall be torn out and properly replaced at the Contractor's expense. Any variation in alignments, grades, plans or sections as herein required shall only be by written consent of the City Engineer.

4. **Provisions for Drainage**
   If it is necessary in the prosecution of the work to interrupt the natural drainage of the surface, or the flow of artificial drains the Contractor shall provide temporary drainage facilities that will prevent damage to public or private interests, and shall restore the original drains as soon as the work will permit. The Contractor shall be held liable for all damages which may result from neglect to provide for either natural or artificial drainage which his work may have interrupted. The Contractor shall be responsible for installing necessary erosion control measures in accordance with Section 720, Best Management Practices, of these Standard Specifications.

   If excavation of road materials indicates seepage of ground water into the area under the road bed subsurface drainage as approved by the City Engineer shall be installed.

   If permanent underground drainage facilities or off-street drainage facilities are required, they shall conform to these Standard Specifications and the Drainage Criteria Manual.

510 - Curb & Gutter

1. General

Construction of curb and gutter, concrete valleys, sidewalks, and driveway approaches shall conform to the following requirements. Concrete shall be Class A per section 200 “Concrete.” No concrete shall be placed until the forms have been checked and approved by the City Inspector. Dimensions and conformation shall comply with the Standard Details appended to these specifications. Grades, alignment, and tolerances shall be as hereinbefore specified.

2. Construction

Forms shall be of wood or metal, of a section satisfactory to the Engineer, straight, free of warp and of a depth equal to the depth of the concrete face. They shall be securely staked to line and grade, and maintained in a true position during the depositing of concrete. Thin plywood, steel, or other similar material may be used to form short radius curb returns at driveways. The reinforcing steel, if required, shall be placed in position as shown on the typical sections. Care shall be exercised to keep all steel in its proper location.

a. For curb ramp combinations, please reference TxDOT standard detail PED-12A or latest revision thereof.
b. The length of curb and gutter placed in any one day shall be limited to the amount which can be furnished in daylight hours. The concrete shall be of sufficiently dry consistency when placed to permit shaping of the curb without a face form. The concrete shall be spaded along the forms to eliminate honeycomb and the gutter section shall be consolidated by tamping. The top section of curb and gutter shall be formed by a template or “mule” fabricated to match the contour of the curb and gutter. The lip of the gutter shall be “turned down” where necessary to match the adjacent grade of valley gutters.
c. When the concrete has set sufficiently, the top surface shall be finished uniformly with a wood float, and then tooled transversely at five (5) foot intervals and longitudinally at the gutter lip and the back of the curb with a quarter (1/4) inch radius edging tool. Expansion joints with half (1/2) inch thick pre-molded expansion joint filler shall be installed at ends of curb returns, at cold joints between pours, and at other locations required by the Standard Details or as directed by the City Engineer.
d. As an option to the method described above, the concrete may be struck off one-quarter (1/4) inch to half (1/2) inch low, and a mortar topping of the same sand-cement ratio placed to fill the curb and gutter section. Finishing shall then be accomplished as specified above with a full-section mule, wood float, and edging. Topping must be placed while the base concrete is still plastic and prior to initial set. The gutter shall be marked where water and sewer service lines cross under the curb with the letters “W” or “S,” as appropriate. The letters shall be three (3) inches high and shall be imprinted while the concrete is sufficiently plastic to receive a legible impression.
e. Completed curb and gutter, when required, shall be coated immediately with a curing compound as specified under Item 200, “Concrete.” Immediately following the removal of forms, the formed surfaces shall have all honeycomb neatly patched and the surface treated with curing compound.
    i. Backfill shall not be placed against the curb face for at least five (5) days, and the backfill shall not be compacted in a manner that will cause lateral displacement of the curb. Care

shall also be exercised to prevent scarring or defacing of the exposed surfaces with equipment used for backfilling and grading. Compaction testing of the backfill shall occur in accordance with the subgrade testing procedures.

3. Measurement

Curb and Gutter shall be measured by linear foot.

4. Payment

Payment for curb and gutter shall be made on the contract unit price per linear foot complete in place. Said price shall be full compensation for furnishing all materials, labor, equipment, tools and incidentals necessary to complete the work.

511 - Sidewalks & Drive Approaches

1. General

This item shall govern the construction of sidewalks and drive approaches within the City.

2. Construction

a. Sidewalks and Drive Approaches shall conform to the Standard Details appended to these specifications.
b. The subgrade shall be compacted uniformly to the approximate density of the surrounding undisturbed material, and a minimum two (2) inch sand cushion provided on the subgrade.
c. Wire mesh reinforcement shall be provided in both sidewalks and drive approaches. Wire mesh shall be 6” x 6” – 10/10.
d. Expansion joints shall be installed at the intersection of drives and walks, where cold joints occur, and where walks or drives abut other concrete structures. Walks and drives shall have a light brush finish as specified under Section 200, Concrete of these specifications. The edges shall be tooled with a one-quarter (1/4) inch radius edging tool, and walks shall also be tooled transversely at five (5) foot intervals. This pattern shall be continued through the drive approach apron.
e. Curing compound shall be applied to the surface immediately after finishing is completed, when required by weather conditions

3. Measurement

Sidewalks and Drive Approaches shall be measured by the square foot.

4. Payment

Payment for sidewalk and drive approaches shall be made on the contract unit price per square foot complete in place. Said price shall be full compensation for furnishing all materials, labor, equipment, tools and incidentals necessary to complete the work.

512 - Concrete Valleys

1. **General**
   Concrete Valleys shall be constructed in accordance with the Standard Details and to the grades indicated on the plans.

2. **Construction**
   Transitions to and from the standard curb and gutter sections at each end shall be such that water will not be trapped in the gutter section. The structure shall be monolithic with the curb and gutter at either end. Valleys shall have a wood float finish with transverse tooled joints as shown in the details. Steel reinforcement shall be provided as shown.

   Concrete shall conform to the requirements of Item 200 – Concrete.

3. **Measurement**
   Concrete Valleys shall be measured by the square foot.

4. **Payment**
   Payment for sidewalk and drive approaches shall be made on the contract unit price per square foot complete in place. Said price shall be full compensation for furnishing all materials, labor, equipment, tools and incidentals necessary to complete the work.

520 - Subgrade

1. Material

Lime for subgrade stabilization shall conform to the requirements of Item 260 of the TxDOT Standard Specifications, or the latest revision thereof.

2. Subgrade Sampling

a. Samples shall be obtained of the predominant subgrade materials from the street right-of-way.
b. Sampling must be performed in one of two methods:
    i. Subgrade physically exposed prior to sampling
        A. City Engineer or designated representative must approve subgrade sampling methods and locations prior to or during testing.
    ii. Subgrade sampled through geotechnical boring
        A. Sampling locations shall be selected at intervals not to exceed three hundred (300) feet or as selected by a licensed geotechnical engineer.
c. Each sample shall consist of approximately two (2) pounds of material and should be properly identified as to sampling location and sampling depth interval.
d. The sample shall be representative of the twelve (12) inches below subgrade elevation. It should be cautioned that the top twelve (12) inches of the natural soil profile is not necessarily representative of the subgrade.
e. Notations shall be made of any fill areas, soft ground conditions, groundwater, or other unusual situations which may influence the pavement design. Sampling should not be from previously backfilled trenches.

3. Lab Testing

a. All samples of subgrade materials shall be visually examined in the laboratory for the initial soil classification and color description.
b. Samples which visually appear to be similar shall be grouped together. This process is very important since subsequent testing is performed on these grouped samples.
c. Representative samples from each of these groups shall be tested for the following properties:

    Liquid Limit (LL)

    Plastic Limit (PL)

    Plasticity Index (PI)

    Percentage Passing No. 200 Mesh Sieve

    Optimum Moisture Content

    Modified Proctor Density

d. All samples shall be stored until the project is complete. These samples may be useful during construction as an aid in identifying the various subgrade groups.

4. Subgrade Group Classification Procedure

a. Compare the results of the Atterberg Limits tests (LL and PI) with Table 520.1: Subgrade Classification Groups by Soil Test Results to obtain the subgrade group. Values which fall on the borderline between two (2) groups should be assigned the group number of the poorer soil group.

b. The resulting subgrade group may be upgraded one (1) group if less than forty (40) percent of the material passes the No. 200 mesh sieve. This applies only to groups III through VII.

Table 520.1 Subgrade Classifications Groups by Soil Test Results			
Group No.	**Liquid Limit**	**Plasticity Index**	**Typical Material Description**
I	<35	5-15	Limestone, weathered limestone, or severely weathered limestone
II	30-40	10-25	Sandy clays, silty clays, or severely weathered limestone
III	40-50	15-30	Sandy clays, silty clays, or severely weathered limestone
IV	50-60	20-35	Clay or silty clay
V	60-70	25-40	Clay
VI	70-80	35-50	Clay
VII	>80	40-60	Clay

5. Subgrade Preparation

a. If subgrade consists of fill material or natural, non-lime-stabilized material the top six (6) inches shall be compacted as required to ninety-five (95) percent modified Proctor Density.

b. Lime Stabilized Subgrade should be constructed in accordance with TxDOT Item 260, Lime Treatment Road Mixed, or latest revision thereof, using the quantity of hydrated lime required by the design procedure. Hydrated lime should meet the requirements of TxDOT Item 260. The well-mixed and cured soil-lime mixture should be compacted to a minimum of ninety-five (95) percent of ASTM D1557 or TEX-121-E maximum density at ±2% of optimum moisture content. In accordance with TEX-115-E, approved lime-stabilization procedures follow.

c. The existing subgrade shall be pulverized to a depth of six (6) inches and shall be treated with lime and water either in the form of a slurry or the materials may be applied to the subgrade separately.

d. The lime and moisture are to be uniformly mixed with the subgrade by the use of an approved pulvi-mixer. The section will then be brought to proper crown and grade. In the event that all clods and lumps are not sufficiently broken up by the pulvi-mixer, the soil-lime mixture shall be allowed to cure from two (2) to four (4) days as directed by the City Engineer. During the curing period, the material shall be kept moist as directed. After the curing is completed, the final mixing shall begin. The mixture (exclusive of all plus half (1/2) inch non-slaking aggregates) when properly mixed shall meet the following requirements when dry screened on a dry weight basis.

Passing 2” Screen 100%

Passing ½” Screen, Minimum 60%

e. Water shall be added during the mixing of soil and lime to attain the optimum moisture content, within ±2%, to ninety-five (95) percent maximum density as determined by the modified Proctor method, ASTM Designation D1557 or TEX-121-E, or latest revision thereof.

f. After compaction is completed, the surface shall be shaped, water added as needed and finish rolled as directed with a pneumatic or other suitable roller sufficiently light to prevent cracking.

g. The completed section shall be moist cured until such time as the first course of base material is placed and compacted.

530 - Flexible Base Course

1. Materials

Flexible Base Material shall conform to the requirements of Item 247 of the TxDOT Standard Specifications and be obtained from approved sources.

The material when tested by "Ball Mill Method for Determining the Disintegration of Flexible Base Material", or latest revision thereof, according to the latest procedures of TxDOT, shall not develop more than fifty (50) percent soil binder prior to rolling.

Materials passing the No. 4 sieve shall be known as "Binder." The portion of material passing the No. 40 sieve shall be known as "Soil Binder" and shall meet the following requirements:

a. The liquid limit shall the values in TxDOT 247 when tested in accordance with AASHO designation T89-49.
b. The plastic limit shall be determined by testing in accordance with AASHO designation T90-49.
c. The plasticity index shall be in accordance with TxDOT 247 and Tex 106-E.

   The preparation of samples for testing according to AASHO designations T89-49, T90-49, TxDOT 247, and Tex 106-E shall be according to AASHO designation T146-49 "Wet Preparation of Disturbed Soil Samples for Test."

   Materials retained on the No. 4 sieve shall have a percent wear of not more than 45 when tested according to AASHO designation T96-15 "Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine," or latest revision thereof.

2. Construction

Prior to placing the flexible base material on the subgrade, the surface of the subgrade shall be bladed and rolled, as necessary and to the extent directed in order to place the subgrade in an acceptable condition to receive the base material. The surface of the subgrade shall be smooth and conform to line and grade as established and in conformity with the typical section as shown on the plans. Sufficient subgrade shall be prepared in advance to ensure satisfactory prosecution of the work.

Where the base course exceeds six (6) inches in thickness, it shall be constructed in two (2) or more courses of equal thickness as indicated on the typical section.

Immediately before placing the base course material, the subgrade shall be checked as to conformity with grade and section. The surface of the subgrade shall not show deviations in excess on one quarter (1/4) inch of five (5) feet, nor one-half (1/2) inch in sixteen (16) feet longitudinally.

The base course material shall be delivered in approved vehicles of uniform capacity, and the required amount of specified material shall be delivered to secure the proper thickness of completed base course. Material deposited on the subgrade shall be spread and shaped the same day. All material shall be moved at least once from the original position in which it is deposited. The material shall be sprinkled, if directed, and shall then be bladed and shaped to conform to the typical section as shown on the plans. All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well graded material as directed by the Engineer. If additional binder is considered desirable or necessary after the material is spread and shaped, it shall be furnished and applied in the amount directed by the Engineer. Such binder shall be carefully incorporated with the other approved methods. The course shall be sprinkled as required and

compacted to the extent necessary to provide not less than the percent density as hereinafter specified. After each section of flexible base is completed, tests as necessary will be made. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with typical sections shown on the plans and to the established lines and grades. On the surface where pavement is to be placed, any deviation in excess of one-fourth (1/4) inch in cross-section and in length of sixteen (16) feet measured longitudinally or areas deficient by more than ½" in thickness shall be corrected by loosening, adding or removing material, reshaping and re-compacting by sprinkling and rolling. All irregularities, depressions, or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and re-compacting by sprinkling and rolling.

The base material shall be compacted at ±2% of optimum moisture content to ninety-eight (98) percent modified Proctor Density as determined by ASTM Designation D1557 or TEX-113-E.

In accordance with TxDOT 247.4.3.2, or latest revision thereof, the Engineer will determine roadway density and moisture content of completed sections in accordance with TEX 115-E. The Engineer may accept the section if no more than 1 of the 5 most recent density tests is below the specified density and the failing test is no more than 3 pct. below the specified density.

540 - HMAC

1. Materials

All bituminous materials shall conform to the TxDOT Standard Specification Item 300, types and grades as indicated below:

Table 540.1 Bituminous Materials Requirements	
Tack Coat	CSS-1H or SS-1H RC-250 with prior engineer approval
Prime Coat	AE-P or MC-30 If near a residential area, AE-P is required due to fumes.
Asphalt for Hot-Mix Asphaltic Concrete	AC-10
Asphalt for 2-Course Surface Treatment	AC-3 or AC-5

2. Construction Methods

Prime coat, tack coat, and HMAC surface course or courses shall be placed in accordance with the following:

a. Prime Coat
   i. All base courses to receive asphaltic concrete pavement shall be cleaned and primed with a uniform application of asphaltic material as specified above.
   ii. The priming material shall be applied with a self-propelled pressure distributor sprayer, except in places impossible to use a sprayer, a rate of zero point fifteen (0.15) to zero point three (0.3) gallons per square yard of surface as determined by the Engineer.
   iii. Subsequent application of pavement course shall not be laid until the primed surfaces have cured long enough to evaporate the volatiles.
   iv. Alternate methods of application at the same coverage rates shall be used where the pressure distributor sprayer cannot be used.

b. Tack Coat
   i. When required to obtain a satisfactory bond between courses or between the prime coat and surface course, a tack coat shall be applied prior to placing the next course.
   ii. Tack coat material shall be as specified under “Materials” above.
   iii. The course to which the tack coat is applied shall be swept clean before the tack is applied.
   iv. The asphalt tack coat material shall be applied uniformly with a sprayer at a maximum coverage of zero point ten (0.10) gallons per square yard of surface as directed by the Engineer.
   v. The surface of curbs, gutters, vertical faces of existing pavements, and all structures in actual contact with asphalt mixes shall be painted with a thin, complete coating of asphaltic tack coat material to provide a closely bonded, water-tight joint.

c. Hot Mix Asphaltic Concrete
   i. Construction methods shall conform to the requirements of TxDOT Item 340, or latest revision thereof, Standard Specifications for Construction of Highways, Streets, and Bridges. Materials shall be as specified above.
   ii. The compacted thickness or depth of the asphaltic concrete surface course shall be as required by City Standards in the minimum surface course thickness. Where the plans require a depth or thickness of the surface course greater than two (2) inches, it shall be accomplished by constructed multiple courses of approximately equal depth.

iii. All asphaltic concrete material shall be placed and rolled during daylight hours.
iv. The mixture shall be at a temperature between two-hundred twenty-five (225) degrees F and three hundred twenty-five (325) degrees F when placed.
v. During the application of asphaltic material, care shall be taken to prevent splattering on adjacent pavement, curbs, gutters, and other structures.
vi. Joints
    A. The placing of the mixture shall be as continuous as possible, and the roller shall pass over the unprotected edge of the freshly laid mixture only when the laying is discontinued for such length of time as will permit chilling or cooling of the mixture.
    B. In every case when resuming the work, the material previously laid shall be cut back to produce a slightly beveled edge for the full depth of the course.
    C. The material cut away shall be removed from the site of the work. Fresh mixture shall be laid against the fresh cut.
    D. Construction joints shall be either parallel to or at right angles to the longitudinal axis of the work.
vii. Compaction
    A. The edges of the pavement along curbs, headers, manholes, valves boxes, and similar structures, and all places not accessible to the roller, or such areas where proper compaction cannot be obtained with the roller, shall be compacted with lightly oiled hand operated vibrating rollers, mechanical tamps, or hand tamped.
    B. Compaction shall be in accordance with the requirements in TxDOT Item 340, or latest revision thereof, with regards to acceptable In-Place Air Voids.
viii. Testing
    A. The surface of the pavement, after final compaction, shall be smooth and true to the established line, grade, and cross section, and shall have no deviation in excess of one eighth (1/8) inch per foot from the nearest point of contact when tested with a sixteen (16) foot straight-edge placed parallel to the centering of the roadway.
    B. The maximum ordinate measured from the face of the straight-edge shall not exceed one-quarter (1/4) inch at any point.
    C. All areas not complying with these requirements shall be corrected.
    D. When required by the City Engineer, the completed pavement shall be sampled and tested for thickness and density.
        1). The testing agency will cut cores from the pavement at locations selected by the City Engineer in order to determine if the specified thickness, stability, and density have been obtained.
        2). If any core indicates a deficient thickness, the Contractor may cut additional cores at his own expense in order to define the area of deficiency.
        3). The Contractor shall remove and repair the areas of deficient thickness, stability, or density, designated by the Engineer at no extra cost.

d. Two Course Surface Treatment
    i. Prime coat shall be required on all base course surfaces, as specified above for HMAC pavement, prior to construction of the two (2) course surface treatment.
    ii. Materials shall be as specified in TxDOT Item 316.

3. Pavement Thickness

a. Each street must be assigned one of the traffic classifications per the definitions in the ordinances. The City Engineering Department must approve these traffic classifications during the design review phase.
b. Table 540.1 Pavement Thickness Design Table can then be used with the subgrade classification group to determine the total required pavement thickness.

Table 540.1 Pavement Thickness Design Table

Street Classification	Subgrade Group No.	Min. Surface Course Thickness (in)	Minimum Total Pavement Thickness (in)
Residential	I	1.5	7.5
	II	1.5	8.5
	III	1.5	9.5
	IV	1.5	12
	V	1.5	14
	VI	1.5	16
	VII	1.5	18
Collector	I	2	7.5
	II	2	9
	III	2	11.5
	IV	2	14
	V	2	16
	VI	2	18
	VII	2	22
Arterial	I	2	8
	II	2	10
	III	2	12.5
	IV	2	15
	V	2	17.5
	VI	2	20
	VII	2	24

c. The pavement section will consist of hot-mix asphaltic concrete surface (thickness as indicated in Table 540.1) overlying a crushed limestone base material.
d. For pavements designed for subgrade groups IV through VII, a select sub-base layer may be substituted for a portion of the base layer. The select sub-base material, placed on top of the subgrade and below the imported base material, must be classified using the subgrade classification procedure and a subgrade group assigned to the sub-base material. The pavement thickness required above the sub-base material is determined using the design charts and the group classification determined for the select sub-base material.

   To determine the minimum required thicknesses for each layer in the pavement design when select sub-base is utilized, the procedure is as follows:

   i. Classify the native subgrade and select sub-base layers by Subgrade Classification Group Number using Table 520.1.

ii. Determine the required Minimum Total Pavement Thickness for the native subgrade's Subgrade Group Number (and street classification) using Table 540.1.
    A. Subtract the Minimum Surface Course Thickness from the Minimum Total Pavement Thickness to determine the Minimum Base Thickness (MBT) required for the native subgrade.
iii. Determine the required Minimum Total Pavement Thickness for the select sub-base's Subgrade Group Number (and street classification) using Table 540.1.
    A. Subtract the Minimum Surface Course Thickness from the Minimum Total Pavement Thickness to determine the MBT required above the select sub-base.
iv. Subtract the number calculated in iii.A. (MBT above the select sub-base) from the number calculated in ii.A. (MBT for the native subgrade). The resulting number is the minimum thickness for the select sub-base layer.
v. The layers of the pavement, when select sub-base is used, will consist of (from the top to the bottom):
    A. Top Layer of HMAC surface course (thickness determined in Table 540.1)
    B. Layer of base material (thickness determined in step iii.A.)
    C. Layer of select sub-base material (thickness determined in step iv.)

The select sub-base material must meet the following installation requirements:

i. Compacted to a minimum of ninety-five (95) percent maximum density as determined by the Modified Proctor Compaction Test (ASTM D1557, latest revision).
ii. Moisture shall be within ±2% of optimum moisture.

550 - Railing

1. Metal Beam Guard Rail/Fence

Metal beam guard rails shall conform to TxDOT Item 540 “Metal Beam Guard Fence” and the standard details listed below, or latest revision thereof.

Texas Department of Transportation standard details for metal beam guard fence:

- GF(31)-14 Metal Beam Guard Fence
- GF(31)DAT-14 Metal Beam Guard Fence (Downstream Anchor Terminal)
- GF(31)LS-14 Metal Beam Guard Fence (Long Span)
- GF(31)TR-14 Metal Beam Guard Fence Transition (Thrie Beam Transition)
- GF(31)TL2-11 Metal Beam Guard Fence Transition (TL2)(Low Speed Transition)
- GF(31)T101-13 Metal Beam Guard Fence Transition (TL101)
- GF(31)T6-14 Metal Beam Guard Fence Transition (T6)
- GF(31)MS-11 Metal Beam Guard Fence Transition (Mow Strip)
- MBGF-11 Metal Beam Guard Fence
- MBGF(SR)-11 Metal Beam Guard Fence (Short Radius Rail)
- MBGF(TR)-11 Metal Beam Guard Fence Transition (Thrie Beam Transition)
- MBGF(TL2)-11 Metal Beam Guard Fence Transition (TL2)(Low Speed Transition)
- MBGF(T101)-11 Metal Beam Guard Fence Transition (TL101 Bridge Rail)
- MBGF(MS)-11 Metal Beam Guard Fence Transition (Mow Strip)

2. Railing

Railings shall conform to TxDOT Item 450 and TxDOT standard details, or latest revision thereof. TxDOT has standard details for Flexible Barriers (or Metal Beam Guard Fences), Steel Barriers, and Rigid Barriers (Concrete Safety Barriers), Guardrail End Treatments, Cable Barrier Systems. Construction shall be done in accordance with all applicable TxDOT details.

3. Measurement

Railings shall be measured by the linear foot, complete in place.

4. Payment

The payment for railings shall be by the linear foot, complete in place. Payment shall include all labor, tools, excavation, backfill, concrete footings, equipment, etc. necessary for the installation of a complete railing in accordance with these specifications.

560 - Traffic Control

1. **General**
   Detours and traffic control plans shall conform to TxDOT Items 502 and 508 and the TxDOT Manual on Uniform Traffic Control Devices (MUTCD), or latest revision thereof. MUTCD Part 6 “Temporary Traffic Control” discusses rerouting traffic and provides standard details depending on the size of the road and the size of the work area.

2. **Requirements**
   A Traffic Control Plan will be required for all work that occurs in the public Right of Way that may impact the drivability of the roadway. This includes construction that occurs on the shoulder or within the parkway of the Right of Way.

   The traffic control plan will be designed, signed, and sealed by an engineer licensed in the State of Texas. The plan will be submitted for review prior to the start of construction to the City and TxDOT (if a TxDOT roadway is affected by the plan).

3. **Measurement**
   The Traffic Control Plan and the implementation of the traffic control plan will be measured by the “Lump Sum,” as the work progresses.

4. **Payment**
   Payment for the Traffic Control Plan and the implementation of the traffic control plan will be by the “Lump Sum,” and will include all engineering, traffic control devices, signage, labor, equipment, tools, and appurtenances necessary to implement a traffic control plan for the duration of the project.

570 - Excavation and Fill

1. General

All excavation, construction of fills or embankments and grading within the public right-of-way shall conform to the following requirements. All completed work shall conform to the plans and applicable Standard Details and shall be accomplished as specified hereinafter.

2. Construction

a. Excavation shall be in accordance with the lines, grades, and typical sections as shown on the plans or established by the Engineer. Unless otherwise shown on the plans or established by the Engineer, street excavation will be made to the subgrade.

b. Embankments (Fills): Prior to placing fill material, the area on which the fill is to be placed shall be cleared of all trees, brush, stumps, and other obstructions.

Embankments shall be constructed of suitable materials approved by Engineer and shall be placed in successive horizontal layers of not more than eight (8) inches in depth, loose measurement, for the full width of the embankment and in such lengths as designated. Stumps, trees, rubbish, vegetation or other unsuitable materials shall not be placed in embankments. All construction traffic shall be uniformly distributed over the entire surface of each layer of the embankment.

A “Maintainer,” or a “Blade Grader” weighing at least three (3) tons, with a blade at least ten (10) feet in length shall be kept in operation on the embankment for the purpose of uniformly mixing, spreading, pulverizing, and consolidating the embankment material.

After a layer of embankment material has been placed and bladed, it shall be sprinkled, if directed, in the quantity as determined by the Engineer, and rolled-to-compaction with a tamping roller, of approved type.

Embankment placed over and adjacent to pipes, culverts, and other structures shall be of suitable materials, and shall be placed in successive horizontal layers of not more than eight (8) inches in depth, loose measurement, and each layer uniformly mixed, pulverized and thoroughly compacted to the satisfaction of the Engineer, by the use of rakes, hand tamps, and/or other approved methods.

Special care shall be taken to prevent any wedging action against the structure. This method of consolidation and compaction shall be used for such distances along embankment adjacent to structures as may be necessary and in other areas where blading and rolling would be impractical.

Where a large portion of the materials excavated consist of rock, the rock may be used in the construction of the embankment as hereinafter specified.

The maximum dimension of any rock used shall not exceed fifty (50) percent of the height of the embankment and in no case shall any rock over twenty-four (24) inches in its maximum dimension be placed in any street embankment. When the greater portion of the embankment is to compose of materials other than rock, the embankment shall be constructed as required in the preceding paragraphs, and the rock shall be carefully distributed throughout the embankments and filled around with earth or other approved fine material so that the interstices between the large particles are filled and a dense, compacted, uniform embankment is secured.

The upper layer of all embankments shall be composed of soil without objectionable quantities of rock within all public rights of way and easements in quantities sufficient to support and grow vegetation at the time of final stabilization.

All embankments for public improvements shall be compacted for the full depth to a density of ninety-five (95) percent of maximum density as determined by the modified Proctor method, ASTM Designation D1557.

3. Payment

Payment for this item shall be subsidiary to the structure or item that requires the embankment or excavation. Payment shall include all labor, equipment, materials, and tools required to complete the installation in accordance with these specifications and the plans.

Specifications 600-699: Storm Drainage

600 - General

This item includes the construction of underground storm drainage facilities. Storm drainage facilities include inlets, manholes, pipe drains, culverts, headwalls, and pipe underdrains. Storm drain facilities shall be designed in accordance with the latest version of the City of Copperas Cove Drainage Criteria Manual. All storm drains shall discharge into larger collector drains or outfall into natural major drainageways or streams within the same drainage area in such a manner as to not endanger downstream property or facilities from increased or concentrated flows caused by the storm drainage facility. Design of all storm drainage facilities must be approved by the City Engineer. Materials and construction methods shall conform to requirements specified hereinafter.

610 - Storm Drain Lines and Culverts

1. **General**
   This item governs the materials used and the constructing, furnishing and placing of storm drain lines and culverts on a prepared grade at the location shown on the Drawings.

2. **Materials**
   Storm drain lines and culverts materials and construction shall conform to Items 460, 462, and 464 of the Texas Department of Transportation Standard Specifications, or the latest revision thereof. Pipe jointing materials shall be rubber gaskets or cold applied preformed plastic gaskets unless otherwise approved by the City Engineer. Bedding shall be Class B. Pipe shall be precast reinforced concrete unless otherwise approved.

   Storm drain shall be reinforced concrete pipe (RCP), ASTM C76, minimum class III, and minimum eighteen-inch diameter. For areas where the minimum cover cannot be met, a concrete cap designed by an engineer will be required for paved areas.

   Storm drains crossing less than six (6) inches over or under an existing or proposed water, wastewater, or similar utility shall have concrete encasement placed in a manner to support both the storm drain and utility.

   Refer to the Drainage Design Section of the IDCM for the use of High Density Polyethylene (HDPE) storm drain line. Outfall structures shall be constructed of reinforced concrete, and the connection with the outfall structure shall be accomplished with RCP. A transition fitting from HDPE to RCP shall be made upstream of the outfall structure. If high density polyethylene pipe (HDPE) is used, the pipe and fittings shall be manufactured in accordance with ASTM F2306 and ASTM D3350.

   The use of Corrugated Metal Pipe (CMP) where properly zoned for driveway culverts shall be limited to residential driveways or areas with prior written approval by the City Engineer and Public Works Department.

3. **Measurement**
   Storm Drain Lines and culverts shall be measured by the linear foot, from center of manhole, bend, or inlet to center of manhole, bend, inlet, or outlet.

4. **Payment**
   Payment for Storm Drain Lines and culverts shall be by the price bid per linear foot, complete in place. Such payment shall include all fittings, excavation, backfill, concrete encasement (if required), labor, tools, equipment, and appurtenances necessary to have a complete and installed storm drain line or culvert.

620 - Manholes, Junction Boxes, and Inlets

1. General

This item governs the materials used and the constructing, furnishing and placing of manholes, junction boxes, and inlets at the locations shown on the Drawings.

2. Materials

Junction boxes and manholes shall be reinforced concrete, Class A concrete per section 200 – Concrete. Junction boxes in lieu of manholes shall be provided where any pipe opening exceeds thirty-seven (37) inches in diameter and where the distance from the outside surfaces of any two (2) pipes entering a manhole is less than one (1) foot, measured along the inside of the manhole.

Manholes, Junction Boxes, and Inlets shall conform to Items 465 and 471 of the Texas Department of Transportation Standard Specifications. Curb inlets shall conform to Texas Department of Transportation (TxDOT) Dallas district design standards listed below, or latest thereof.

Texas Department of Transportation Dallas district standard details:

- No. 1: Type 1 Curb Inlet for Use W/ 5” to 8” Barrier Curb – 5’, 10’, 15’, and 20’ Openings 3’6” to 10’0” Depths and 3’, 4’, and 5’ Widths
- No. 2: Type 1-C Curb Inlet on Box Culvert for Use W/ 5” to 8” Barrier Curb – 5’, 10’, 15’ and 20’ Openings
- No. 3A/3B: Type 2 Curb Inlet for Use W/ 5” to 8” Barrier Curb – 5’, 10’, 15’, and 20’ Openings
- No. 4A/4B: Type 2-C Curb Inlet on Box Culvert for Use W/ 5” to 8” Barrier Curb – 5’, 10’, 15’ and 20’ Openings
- No. 5A/5B: Type 1 Curb Inlet
- No. 6A/6B: Type 1 Curb and Grate Inlet
- No. 9A/9B: Type 2 Rail and Grate Inlet
- No. 10: Standard Recessed Storm Drainage Inlets, Curbs, and Type A Manhole Frame and Cover
- No. 14: Traffic Bearing Drop Inlet Type D Details

3. Measurement

Manholes, junction boxes, and inlets shall be measured by each complete installation in place.

4. Payment

Manholes, junction boxes, and inlets shall be paid by each complete installation in place. This includes excavation, backfill, compaction, concrete collar (if manhole is in the street), watertight pipeline connections, labor, tools and equipment to install a complete and working manhole, junction box, or inlet.

630 - Headwalls

1. **General**
   This item governs the materials used and the constructing, furnishing and placing of headwalls at the locations shown on the Drawings.

2. **Materials**
   Headwalls must be designed by a licensed engineer, unless TxDOT design standards, specifications and details are used. Headwalls shall be designed in accordance with TxDOT Standard Specifications, TxDOT Item 466, Concrete shall be Class A per section 200 – Concrete.

3. **Measurement**
   Headwalls shall be measured by each complete installation in place.

4. **Payment**
   Headwalls shall be paid by each complete installation in place. This includes excavation, backfill, compaction, watertight pipeline connections, labor, tools and equipment to install a complete and working headwall.

640 - Precast Safety End Treatments

1. **General**
   This item governs the materials used and the constructing, furnishing and placing of Precast Safety End Treatments at the locations shown on the Drawings.

2. **Materials**
   Precast Safety End Treatments shall be designed by a licensed engineer, unless TxDOT design standards, specification, and details are used. Precast safety end treatments shall be designed in accordance with TxDOT Standard Specifications, TxDOT Item 467.

3. **Measurement**
   Precast safety end treatments shall be measured by each complete installation in place.

4. **Payment**
   Precast safety end treatments shall be paid by each complete installation in place. This includes excavation, backfill, compaction, watertight pipeline connections, labor, tools and equipment to install a complete and working precast safety end treatment.

650 - Pipe Underdrains

1. **General**
   This item governs the materials used and the constructing, furnishing and placing of Pipe Underdrains at the locations shown on the Drawings.

2. **Materials**
   Pipe Underdrains shall conform to Items 556 of the Texas Department of Transportation Standard Specifications, of the type pipe approved for use.

3. **Measurement**
   Pipe underdrains shall be measured by the linear foot of the complete installation in place.

4. **Payment**
   Pipe underdrains shall be paid by the amount bid for each linear foot of the complete installation in place. This includes excavation, backfill, compaction, watertight pipeline connections, labor, tools and equipment to install a complete and working pipe underdrain system.

660 - Walls

1. General

This item governs the materials and construction of retaining walls. Refer to Building Code for Retaining Wall requirements

2. Concrete Retaining Walls

a. General

Concrete Retaining walls shall be designed in accordance with either American Association of State Highway and Transportation Officials (AASHTO) current standards or International Building Code (IBC)/American Concrete Institute (ACI) 138 or latest revisions thereof.

All forms and forming, placement of reinforcement, placement of Portland cement concrete, form removal, finishing and curing shall conform to Item 200 (Concrete) of this specification. Cast-in-place Portland cement concrete retaining walls shall be constructed in one continuous vertical pour from the top of the footing to the top of the wall unless intermediate horizontal construction joints are shown on the Drawings.

The height of the retaining wall will be determined by established grades or as directed by the Engineer or designated representative but and shall be such that water will not be trapped or ponded on private or public property.

Reinforcement for the wall shall be as indicated on the Drawings. The Contractor shall provide dowel bars of the proper size, shape and spacing, as indicated on the drawings.

Devices to release the hydrostatic head shall be installed as indicated on the drawings.

All exposed corners and edges shall be filleted with triangular chamfer strips measuring ¾ inch on each side. Exposed horizontal surfaces shall be level and flat, and exposed vertical surfaces shall be plumb and flat, unless indicated otherwise on the Drawings.

b. Vertical Control Joints

Unless indicated otherwise on the Drawings, vertical control joints shall be constructed in the retaining wall stem (the vertical portion of the wall) to create planes of weakness to control cracking. Horizontal wall reinforcement shall extend through the vertical control joints. These joints shall be constructed at abrupt changes in wall height and at a spacing not to exceed 20 feet in wall sections of uniform. The joints shall be formed by placing triangular chamfer strips to create grooves in both faces of the wall to a depth of at least ten percent of the wall thickness. Control joints shall be sealed, on the backfilled side of the retaining wall, with a non-sag low-modulus silicone sealant, or, alternatively, the joint may be covered with a waterproofing material consisting of an 18-inch wide strip of self-adhering polyethylene having a rubberized asphalt mastic, as approved by the Engineer or designated representative.

c. Vertical Expansion Joints

Vertical expansion joints shall be constructed at a spacing not to exceed 60 feet, unless indicated otherwise on the Drawings. They shall extend the full height and width of the wall, including the wall footing, and shall consist of sleeved dowels and ½-inch thick preformed bituminous fiber material. The edges and corners of the joints shall be formed by triangular chamfer strips measuring ¾ inch on each side. The concrete on the two sides of an expansion

joint shall be placed in two separate pours unless approved otherwise by the Engineer or designated representative.

d. Construction Joints

Construction joints shall be in accordance with the drawings. Wall reinforcement shall extend through the construction joint unless indicated otherwise on the Drawings.

e. Waterstops

Waterstops shall be provided in construction and expansion joints in retaining walls where water-tightness is essential to the function of the structure, as in detention, retention, or water quality ponds or flood walls.

3. Dry Stack Rock Wall

This section shall govern furnishing and placing dry stack gravity rock walls in conformance with the standard details and the Drainage Criteria Manual and as herein specified on a prepared subgrade, including the excavation and backfilling for the wall, to the height, lines, grades, details and locations indicated on the Drawings or as established by the Engineer or designated representative.

Native Rock shall be durable weathered field limestone of suitable quality to ensure permanence in the structure.

4. Mortared Rock Wall

This section shall govern the construction of mortared rock walls, as herein specified, on a prepared subgrade, including furnishing the stone, mortar and other related materials to construct walls, the excavation and backfilling the wall, removal of any old structure or portions thereof encountered, disposal of surplus excavated material and the completion Mortared Rock Walls as indicated on the Drawings or as directed by the Engineer or designated representative.

a. Materials

i. Rock: All types used shall be native limestone suitable for horizontal course type construction. The size of rock to be used for construction shall be as indicated on the Drawings, but may vary as approved by the Engineer or designated representative.
ii. Portland Cement: ASTM C 150, Type I
iii. Masonry Cement: ASTM C 91
iv. Sand: ASTM C 144, Natural
v. Water: Free from matter that could impair suitability for use in mortar
vi. Hydrated Lime: ASTM C 207, Type S
vii. Mortar: Mortar shall be composed of 1-part Portland Cement, 1-part hydrated lime and 6 parts sand (by volume) and water. Mortar shall have a consistency that ensures that it can be easily spread by a trowel. An alternate mix composed of 1-part masonry cement and 3 parts sand may be used. The sand shall be measured damp and loose.

b. Construction Methods

Stone shall be laid plumb, level or true to a line. All stone shall be laid in a full bed of mortar with head joints and edge joints completely filled. The face shall be aligned or exposed as indicated on the Drawings. Exterior joints that will remain exposed shall be finished in a manner approved by the Engineer or designated representative.

In hot weather, stone work shall be kept moist until the mortar has set. No mortar work will be done when the temperature is below 40°F in the shade and all work may be suspended during

freezing or undesirable weather. The mortar materials shall be mixed mechanically for not less than 5 minutes after all ingredients are in the mixer. Mortar that has begun to set or that has been mixed for more than 2 hours shall not be used.

Spalls may be used in partially filling the large voids, provided they are keyed in properly and are well coated with mortar. All finished rockwork shall be protected from damage. Chipped rockwork, that will remain exposed, shall be satisfactorily repaired or replaced.

Mortared rock walls shall consist of courses or layers of rock with the spaces between them filled with mortar and shall be constructed at such places as indicated on the Drawings or as directed by the Engineer or designated representative, in accordance with these specifications and in conformity with the lines, grades, height, depth and other details shown on the pertinent typical sections.

Excavation and concrete footings for mortared rock walls shall not be paid for directly, but shall be included in the unit price bid for mortared rock wall construction.

Prior to placing any material, the footings shall have been placed by the Contractor as part of this contract to the approved line and grade and allowed at least 36 hours curing time. The rock shall then be thoroughly wet and bedded in 1 inch of mortar placed on the footings, one against the other, with the resulting voids being completely filled with mortar. The finished surface shall be even and level.

5. Measurement

Walls shall be measured by the square footage of the front surface area of the wall. Unless shown otherwise, the area will be measured from 1 foot below the finished grade of the ground line on the face of the exterior wall to the top of the wall.

6. Payment

Payment for walls shall be as provided for under E. Measurement at the unit price bid. This payment shall be considered full compensation for all excavation, footings, leveling pads, backfill, cement stabilization (where necessary), furnishing and placing concrete, reinforcing material, filter material, drain pipe, joint material, water stop, anchorage system, and all equipment, labor, tools, and incidentals necessary for a complete and installed wall as detailed on the drawings and specifications, including these standard specifications.

Specifications 700-799: Erosion Control Measures

700 - General

This item includes the specifications for erosion control measures, including silt fencing, rock berms, curb inlet drain filters, etc.

710 - Sodding, Seeding, and Watering

1. **Sodding for Erosion Control**
   Sodding shall be per TxDOT Item 162 “Sodding for Erosion Control” or latest revision thereof.
2. **Seeding for Erosion Control**
   Seeding shall be per TxDOT Item 164 “Seeding for Erosion Control” or latest revision thereof.
3. **Vegetative Watering**
   Watering shall be per TxDOT Item 168 “Vegetative Watering” or latest revision thereof.

720 - Best Management Practices

1. Silt Fence

This item shall govern the provision and placement of a silt fence fabric fence including maintenance of the fence, removal of accumulated silt, removal of the silt fence and re-vegetation of disturbed areas upon completion of the project.

a. Materials

i. Fabric

A. General: The silt fence fabric shall be of nonwoven polypropylene, polyethylene or polyamide thermoplastic fibers with non-raveling edges. The silt fence fabric shall be non-biodegradable, inert to most soil chemicals, ultraviolet resistant, unaffected by moisture or other weather conditions, and permeable to water while retaining sediment. The silt fence fabric shall be supplied in rolls a minimum of 36 inches wide.

B. Physical Requirements: The fabric shall meet the requirements presented in Table 720.1, when sampled and tested in accordance with the methods indicated herein, on the Standard Details and/or on the Drawings.

ii. Posts:

A. Posts shall be steel Tee or Y-posts, not less than 4 feet in length with a minimum weight of 1.25 pounds per foot with a minimum Brinell Hardness of 143. Hangers shall be adequate to secure fence and fabric to posts. Posts and anchor plates shall conform to ASTM A-702.

B. Wire Fence: Wire fence shall be welded wire fabric 2 in. x 4 in. 12.5 SWG, wire diameter 0.099 in (±0.005 in.).

Table 720A.1 Silt Fence Fabric Requirements

Physical Properties	Method	Requirements
Fabric Weight in ounces per square yard	TEX-616-J [1]	5.0 minimum
Equivalent Sieve Opening Size: US Standard	CW-02215 [2]	40 to 100
Mullen Burst Strength: lbs. per sq. inch (psi)	ASTM D-3786 [3]	280 minimum
Ultraviolet Resistance; % Strength Retention	ASTM D-1682 [4]	70 minimum

[1] TxDoT Test Method Tex-616-J, "Testing of Construction Fabrics".

[2] US Army Corps of Engineers Civil Works Construction Guide Specification CW-02215, "Plastic Filter Fabric".

[3] ASTM D-3786, " Test Method for Hydraulic Bursting Strength of Knitting Goods and Nonwoven Fabrics: Diaphragm Bursting Strength Tester Method".

[4] ASTM D-1682, "Test Methods for Breaking Load and Elongation of Textile Fabrics ".

b. Construction Methods

The silt fence fabric shall be securely attached to the posts and the wire support fence with the bottom 12 inches of the material buried in a trench a minimum of 6 inches deep and 6 inches wide to prevent sediment from passing under the fence. When the silt fence is constructed on impervious material, a 12-inch flap of fabric shall be extended upstream from the bottom of the silt fence and weighted to limit particulate loss. No horizontal joints will be allowed in the silt fence fabric. Vertical joints shall be overlapped a minimum of 12 inches with the ends sewn or otherwise securely tied.

The silt fence shall be a minimum of 24 inches high. Posts shall be embedded a minimum of 12 inches in the ground, placed a maximum of 8 feet apart and set on a slight angle toward the anticipated runoff source. When directed by the Engineer or designated representative, posts shall be set at specified intervals to support concentrated loads.

* Per OSHA §1926.701, "all protruding reinforcing steel, onto and into which employees could fall, shall be guarded to eliminate the hazard of impalement". Caps must be large enough to dissipate the forces of impact to prevent impalement from a reasonably foreseeable fall distance. It should be noted that the use of impalement protection caps is but one method of protection; covers or wooden troughs can be another means of meeting the guarding requirement.

The silt fence shall be repaired, replaced, and/or relocated when necessary or as directed by the Engineer or designated representative. Accumulated silt shall be removed when it reaches a depth of 6 inches.

2. Stone Outlet Structure

This item shall consist of a temporary crushed stone dike installed in conjunction with and as part of a diversion dike, interceptor dike or perimeter swale. The purpose of this stone outlet structure is to provide a protected outlet for a diversion dike, interceptor dike or perimeter dike, to provide for diffusion of concentrated flow and to allow the area behind the dike to de-water. This item shall include removal of the "Stone Outlet Structure" and re-vegetation of the area.

a. Materials

i. Stone

The stone used in construction of this stone outlet dike shall be crushed stone at least 3 inches in diameter but not over 6 inches in diameter or ½ cubic foot in volume.

ii. Seeding

Seeding for re-vegetation shall conform to section 710 “Seeding for Erosion Control”.

iii. Fabric Core

A. General: The filter fabric shall be of non-woven polypropylene, polyethylene or polyamide geo-textile with non-raveling edges. The fabric shall be non-biodegradable, inert to most soil chemicals, ultraviolet resistant, unaffected by moisture or other weather conditions, and permeable to water while retaining sediment. The filter fabric shall be supplied in rolls a minimum of 36 inches wide.

B. Physical Requirements: The fabric shall meet the requirements presented in Table 720B.1, when sampled and tested in accordance with the methods indicated herein or on the Drawings.

Table 720B.1 Filter Fabric Requirements

Physical Properties	Method	Requirements
Fabric Weight in ounces per square yard	TEX-616-J [1]	4.5 minimum
Water Flow Rate in gallons/sq. foot/minute	TEX-616-J [1]	40 maximum
Equivalent Sieve Opening Size: US Standard	CW-02215 [2]	40 minimum
Mullen Burst Strength: lbs. per sq. inch (psi)	ASTM D-3786 [3]	250 minimum
Ultraviolet Resistance; % Strength Retention	ASTM D-1682 [4]	70 minimum

[1] TxDOT Test Method Tex-616-J, "Testing of Construction Fabrics".

[2] US Army Corps of Engineers Civil Works Construction Guide Specification CW-02215, "Plastic Filter Fabric".

[3] ASTM D-3786, " Test Method for Hydraulic Bursting Strength of Knitting Goods and Nonwoven Fabrics: Diaphragm Bursting Strength Tester Method".

[4] ASTM D-1682, " Test Methods for Breaking Load and Elongation of Textile Fabrics".

b. Construction Methods

On the area over which the Stone Outlet Structure is to be placed, all clearing, grubbing and excavation operations shall be completed before placing the Stone Outlet Structure. The Stone Outlet Structure foundation soil shall be compacted to the extent necessary to provide an in-place density (TxDOT Test Method Tex-115E) not less than 95 percent of the laboratory density as determined in accordance with TxDOT Test Method Tex-114-E. The stone shall be placed, spread and shaped to the grades indicated on the Drawings and/or Standard Details. All disturbed areas shall be graded and compacted to an in-place density (TxDOT Test Method Tex-115E) not less than 85 percent of the maximum laboratory density (TxDOT Test Method Tex-114-E) and then seeded in accordance with section 710 “Seeding for Erosion Control.”

The stone outlet structure shall be inspected by the Contractor monthly and after each rainfall event with an accumulation of 1 inch or more. Stone shall be replaced when the structure ceases to function as intended due to silt accumulation among the stone, washout, construction traffic damage, etc. When the silt reaches a depth equal to 1/3 the height of the structure or six inches, whichever is less, the Contractor will remove the accumulated silt and dispose of it at a disposal site, that is approved by the Engineer or designated representative, in a manner that will ensure that additional siltation will not occur.

When indicated on the Drawings, the Stone Outlet Structure shall be removed when directed by the Engineer or designated representative and the area leveled off and protected by erosion control measures appropriate for the terrain. Stabilization shall consist of complete vegetation cover, sufficiently established to be erosion resistant.

3. Rock Berm

This item shall govern the construction of a temporary berm of open graded rock that is installed at the toe of a slope on the perimeter of a developing area. Rock berms are appropriate for use as flow diverters, energy dissipators, grade control, and level spreaders to release the water in sheet flow. This item shall also govern the removal of the "Rock Berm" and re-vegetation of the area.

a. Materials

Surplus rock excavated from utility trenches or from other excavations may be used in construction of these berms. In general, the rocks shall be sound with a minimum of 3 inches in smallest dimension and shall weigh between 10 and 30 pounds each. Seeding for re-vegetation shall conform to section 710, "Seeding for Erosion Control".

Use only open-graded rock of the size indicated on the Standard Details with most of the fines removed.

b. Construction Methods

All trees, brush, stumps and objectionable material shall be removed and disposed in a manner that will not interfere with the construction of the berm.

A trench shall be excavated to a minimum depth of 4 inches below existing grade for placement of the rock as indicated on Standard Details and the Drawings. The rocks shall be placed in interlocking layers with close joints starting at the base. Open joints shall be filled with rock-spalled materials as required to stabilize the berm.

The area upstream from the rock berm shall be maintained in a condition, which will allow sediment to be removed following the runoff from a rainfall event. After each rainfall event with an accumulation of 1 inch or more, an inspection of the rock berm will be made by the Contractor and the stone shall be replaced, when the structure ceases to function as intended because of sediment accumulation among the rocks, washout, construction traffic damage, etc.

If the sediment reaches a depth equal to 1/3 the height of the berm or 6 inches, whichever is less, the Contractor will remove the accumulated sediment and dispose of it at an approved disposal site in a manner that will not contribute to additional sedimentation. The berm will be reshaped as needed during construction.

When the site is completely stabilized, the berm will be removed and disposed of in a manner approved by the Engineer or designated representative.

The area will be re-vegetated as required by section 710, "Seeding for Erosion Control".

4. Curb Inlet Drain Filter

a. Material
   i. Filter fabric protection shall be designed and maintained in a manner similar to a silt fence.
   ii. Where applicable, filter fabric, posts, and wire backing shall meet the material requirements specified in the silt fence design requirements.
   iii. Filter gravel shall be ¾ inch (Block and Gravel Protection) or 1-1/2 to 2 inches (Excavated Impoundment Protection) washed stone containing no fines. Angular shaped stone is preferable to rounded shapes.

b. Construction Methods
   i. Maintain barricades, signs, and safety features around the work in accordance with all provisions of the latest edition of the Manual on Uniform Traffic Control Devices (MUTCD) when installing inlet protection on publicly traveled streets or in developed areas. Ensure that inlet protection is properly designed, installed, and maintained to avoid flooding of the roadway or adjacent properties and structures.
   ii. Maximum depth of flow shall be 8 inches or less.
   iii. Positive drainage is critical in the design of inlet protection. If overflow is not provided for at the inlet, excess flows shall be routed through established swales, streets, or other watercourses to minimize damage due to flooding.
   iv. Filter Barrier Protection – Silt Fence shall consist of nylon geotextile supported by wire mesh, W1.4 X W1.4, and galvanized steel posts set a minimum of 1-foot depth and spaced not more than 6 feet on center. A 6-inch wide trench is to be cut 6 inches deep at the toe of the fence to allow the fabric to be laid below the surface and backfilled with compacted earth or gravel. This entrenchment prevents any bypass of runoff under the fence. If the inlet is installed within a paved area, provide sufficient material overlap at the base to allow for anchorage of the fabric to the concrete inlet slab by sand bags or other means in order to prevent bypass or runoff under the fence.

c. Inspection

Inlet Protection shall be inspected regularly (at least as often as required by the TPDES Construction General Permit). When silt fences are also used and the fabric becomes clogged, it should be cleaned or, if necessary, replaced. Also, sediment should be removed when it reaches approximately one-half the height of the inlet protection device. If a sump is used, sediment should be removed when the volume of the basin is reduced by 50%. For systems using filter stone, when the filter stone becomes clogged with sediment, the stones must be pulled away from the inlet and cleaned or replaced. Dispose of clogged filter stone in an approved location.

5. Stone Outlet Sediment Trap

a. Material

Stone Outlet Sediment Traps used in situations where flows are concentrated in a drainage swale or channel are subject to the following design criteria:

i. The embankment shall be placed on geotextile fabric meeting the following minimum criteria:
ii. Tensile Strength, ASTM D4632 Text Method for Grab Breaking Load and Elongation of Geotextiles, 250-lbs.
iii. Puncture Rating, ASTM D4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products, 135-lbs.
iv. Mullen Burst Rating, ASTM D3786 Standard Test Method for Hydraulic Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method, 420-psi.
v. Apparent Opening Size, ASTM D4751 Test Method for Determining Apparent Opening Size of a Geotextile, U.S. Sieve No. 20 (max).

b. Construction Methods

Stone Outlet Sediment Traps for situations where flows are concentrated in a drainage swale or channel are subject to the following installation criteria:

i. The maximum drainage area contributing to the trap shall be 10 acres. For larger drainage areas a sediment basin shall be used.
ii. The minimum storage volume shall be 1800 cubic feet per acre of disturbed land draining to the device.
iii. The surface area of the design storage shall be 1% of the area draining to the device.
iv. The maximum embankment height shall be 6 feet as measured from the toe of the slope on the downstream side.
v. Minimum width of the embankment at the top shall be 2 feet.
vi. Embankment slope shall be 1.5:1 or flatter.
vii. The embankment shall have a depressed area to serve as the outlet with a minimum width of 4 feet.
viii. A six-inch minimum thickness layer of ¾ to 2 inch (1-½ inch nominal) well graded filter stone shall be placed on the face of the embankment.
ix. The embankment shall be comprised of well-graded stone with a size range of 6 to 12 inches in diameter. The stone may be enclosed in wire mesh or a gabion basket and anchored to the channel bottom to prevent washing away.
x. The outlet shall be designed to have a minimum freeboard of 6” at design flow.
xi. Geotextile fabric, covered with a layer of stone, shall extend past the base of the embankment on the downstream side a minimum of 2 feet.

c. Inspection

Stone Outlet Sediment Traps shall be inspected regularly (at least as often as required by the TPDES Construction General Permit) to check for clogging of the void spaces between stones. If the aggregate appears to be silted in such that efficiency is diminished, the stone shall be replaced. Deposited sediment shall be removed when the depth of sediment is equal to one-third of the height of the embankment as measured from the original toe of slope to the crest of the outlet, or has reached a depth of one foot, whichever is less. The removed sediment shall be stockpiled or redistributed in areas that are protected from erosion.

6. Riprap

a. Materials

i. Flexible Erosion Control Mat

Flexible erosion control matting is preferred over loose rock riprap for areas where mowing and grass maintenance is to be performed by the City. The use of grouted rock rip rap or concrete aprons is an acceptable alternative to Flexamat. Flexamat, manufacturer by Motz Enterprises, or pre-approved equal shall be used.

ii. Rock

The rock shall be suitable in all respects for the purpose intended. Rock sources shall be selected well in advance of the time the rock will be required and shall be pre-approved by the Engineer. Rock used for riprap shall be hard, durable, and angular in shape and consist of clean field rock or rough unhewn quarry rock as nearly uniform in section as practicable. Neither the width nor the thickness of a single rock shall be less than one-third of its length. The rocks shall be dense, resistant to weathering and water action, and free of overburden, spoils, shale, and organic material. Shale, chalk, and limestone with shale or chalk seams shall not be acceptable. Rounded rock (river rock) shall not be acceptable.

The rock riprap material shall be provided as a gradation of larger and smaller rock sizes associated with a rock class or median diameter (D50) as specified in the drawings. Rock diameter for angular material represents the length of the intermediate axis of an individual rock. The material gradation shall conform to table below for the class sizes corresponding to the D50. The D15, D50, D85, and D100 are the rock sizes for which 15%, 50%, 85%, and 100% of the total sample are of equal size or smaller, respectively.

Table 720F.1: Rock Riprap Gradation Table								
Rock Rip Rap Class by Median Particle Dia. (D50)		D15 (in)		D50 (in)		D85 (in)		D100 (in)
Class	Dia. (in)	Min	Max	Min	Max	Min	Max	Max
I	6	3.7	5.2	5.7	6.9	7.8	9.2	12.0
II	9	5.5	7.8	8.5	10.5	11.5	14.0	18.0
III	12	7.3	10.5	11.5	14.0	15.5	18.5	24.0
IV	15	9.2	13.0	14.5	17.5	19.5	23.0	30.0
V	18	11.0	15.5	17.0	20.5	23.5	27.5	36.0
VI	21	13.0	18.5	20.0	24.0	27.5	32.5	42.0
VII	24	14.5	21.0	23.0	27.5	31.0	37.0	48.0
VIII	30	18.5	26.0	28.5	34.5	39.0	46.0	60.0
IX	36	22.0	31.5	34.0	41.5	47.0	55.5	72.0
X	42	25.5	36.5	40.0	48.5	54.5	64.5	84.0

Reference: NCHRP Report 568.

Conversion to weight-based gradation: W = 0.0275D3Sg where W is rock size in lbs, D is diameter in inches and Sg is the specific gravity of the rock.

iii. Broken Concrete

The rock used for mortar riprap may consist of broken concrete removed under the contract or obtained from other approved sources. Broken concrete shall be as nearly uniform in section as practicable and of the sizes indicated in section 720F.2.A “Dry Riprap.”

iv. Concrete

Cast in place concrete shall conform to Item 200 of this specification.

v. Grout and Mortar

Grout and mortar shall consist of 1-part Portland Cement and 3 parts sand, thoroughly mixed with water. Mortar shall have a consistency such that it can be easily handled and spread by trowel. Grout shall have a consistency such that it will flow into and completely fill all joints.

vi. Reinforcement

Reinforcement shall conform to Item 200 – Concrete.

vii. Joints

Pre-molded expansion joint material shall conform to Item 200 – Concrete.

viii. Tie Backs and Anchors

Galvanized tie backs and anchors shall be as indicated on the Drawings.

ix. Filter Fabric

Filter Fabric shall conform to section 720 H “Filter Fabric” of this specification.

x. Granular Filter

Aggregate used for granular filters shall conform to section 530 “Flexible Base Course”.

xi. Seed

For vegetated soil-rock riprap, the type of seed mix and application rates shall be as specified on the Drawings and within the referenced Standard Specification. If no seed mix is specified, apply according to section 710 “Seeding for Erosion Control.”

xii. Soil retention blanket

Soil retention blanket shall be per section 720G “Soil Retention Blanket.”

b. Construction Methods

Prior to commencement of this work, all required erosion control and tree protection measures shall be in place and utilities located and protected. Construction equipment shall not be operated within the drip line of trees unless indicated on the Drawings. Construction materials shall not be placed under the canopies of trees. No excavation or embankment shall be placed within the drip line of trees until tree wells are constructed. Spalls and small stones used to fill open joints and voids in rock riprap shall be rocked and wedged to provide a tight fit.

Unsuitable excavated materials or excavation in excess of that needed for construction shall be known as "Waste" and shall become the property of the Contractor and it shall become his sole responsibility to dispose of this material in an environmentally sound manner off the limits of the right of way at a permitted disposal site.

All blasting shall conform to the Copperas Cove Code of Ordinances. The Contractor shall comply with all laws, ordinances, and applicable safety code requirements.

Areas to be protected by rock riprap shall be free of brush, trees, stumps and other objectionable materials and be graded to a smooth compacted surface. All soft or spongy material shall be removed and replaced with appropriate material to the depths shown on the plans or as directed by the engineer. Fill Areas, unless otherwise specified will be compacted in accordance with Sections 520 or 570 of these specifications. Unacceptable subgrade conditions shall be reworked according to the Engineer's recommendations. Excavation areas shall be maintained until the riprap is placed.

i. Dry Rock Riprap

The mass of rock riprap shall be placed as to be in conformance with the required gradation mixtures, to the lines, grades and layers thickness that is shown on the drawings.

When the riprap will be placed on an erodible soil, as determined by the Engineer or designated representative, a layer of geotextile filter fabric or a granular filter layer shall be placed, prior to placement of the riprap material. In some cases multiple layers of granular filter material of varying gradations may be required. The median rock riprap size (D50), rock riprap layer thickness, filter type, when applicable the number of granular filter layers, granular filter aggregate gradations (grade/size classification), granular layer thicknesses shall be specified on the plans. The minimum granular filter layer thickness shall be 4 inches. Geotextile filter fabric shall conform to section 720 H “Filter Fabric” and be installed with sufficient anchoring and overlap between seams according to the manufacturer's recommendations to ensure full filter barrier protection of the subgrade after riprap installation. When specified on the plans a four (4) inch minimum thickness granular cushion layer of gravel or sand may be placed over the filter fabric to prevent damage the fabric during placement of rock riprap.

Rock riprap shall be machine placed and distributed such that there will be no large accumulations of either larger or smaller sizes. Placing rock riprap by dumping into chutes or similar methods shall not be permitted. The rocks shall be placed in a single layer with close joints. The rock riprap layer thickness shall be no less than the specified maximum stone size (D100) or 1.5 times the D50, whichever produces the greater thickness. In areas exposed to flowing water the rock riprap layer thickness should be no less than 2.0 times the D50. The upright axis of the rocks shall make an angle of approximately 90 degrees with the embankment slope. The courses shall be placed from the bottom of the embankment upward, with the larger rocks being placed on the lower courses. Open joints shall be filled with spalls. Rocks shall be arranged to present a uniform finished top surface such that the variation between tops of adjacent rocks shall not exceed 3 inches. Rocks that project more than the allowable amount in the finished work shall be replaced, embedded deeper or chipped.

ii. Mortared Rock Riprap

Rock for this purpose, as far as practicable, shall be selected as to size and shape in order to secure fairly large, flat-surfaced rock which may be laid with a true and even surface and a minimum of voids. Fifty percent of the mass rock shall be broad flat rocks, weighing between 100 and 150 pounds each, placed with the flat surface uppermost and parallel to the slope. The largest rock shall be placed near the base of the slope. The spaces between the larger rocks shall be filled with rocks of suitable size, leaving the surface smooth, reasonably tight and conforming to the contour required on the Drawings. In general, the rocks shall be placed with a degree of care that will ensure plane surfaces with variation from the true plane of no more than 3 inches in 4 feet. Warped and curved surfaces shall have the same general degree of accuracy as indicated for plane surfaces.

Before placing mortar, the rocks shall be wetted thoroughly and as each of the larger rocks is placed, it shall be surrounded by fresh mortar and adjacent rocks shall be shoved into contact. After the larger rocks are in place, all of the spaces or opening(s) between them shall be filled with mortar and the smaller rocks then placed by shoving them into position, forcing excess mortar to the surface and insuring that each rock is carefully and firmly embedded laterally. After the work described above has been completed, all excess mortar forced up shall be spread uniformly to completely fill all surface voids. All surface joints then shall be pointed up roughly, either with flush joints or with shallow, smooth raked joints.

iii. Concrete Riprap

Concrete for riprap shall be placed as indicated on the Drawings or as directed by the Engineer or designated representative. Unless otherwise indicated on the Drawings, concrete riprap shall be reinforced using wire or bar reinforcement.

Concrete shall be Class A or as indicated otherwise on the Drawings and shall conform to section 200 “Concrete.”

When welded wire reinforcement is indicated, it shall be a minimum of 6 × 6 W1.4 × W1.4 with a minimum lap of 6 inches at all splices. At the edge of the riprap, the wire fabric shall not be less than 1 inch nor more than 3 inches from the edge of the concrete and shall have no wires projecting beyond the last member parallel to the edge of the concrete.

When bar reinforcement is used, the sectional area of steel in each direction shall not be less than the sectional area of the wire fabric described above. The spacing of bar reinforcement shall not exceed 18 inches in each direction and the distance from the edge of concrete to the first parallel bar shall not exceed 6 inches.

Reinforcement shall be supported properly throughout the placement to maintain its position approximately equidistant from the top and bottom surface of the slab.

Unless otherwise noted, expansion joints of the size and type indicated on the Drawings shall be provided at intervals not to exceed 40 feet and shall extend the full width and depth of the concrete. Marked joints shall be made 3/8-inch-deep at 10-foot intervals. All joints shall be perpendicular and at right angles to the forms unless otherwise indicated on the Drawings.

Slopes and bottom of the trench for toe walls shall be compacted and the entire area sprinkled before the concrete is placed.

After the concrete has been placed, consolidated and shaped to conform to the dimensions indicated on the Drawings and has set sufficiently to avoid slumping, the surface shall be finished with a wooden float to secure a reasonably smooth surface.

Immediately following the finishing operation, the riprap shall be cured conforming to Section 200 of these specifications.

7. Soil Retention Blanket

This item shall govern the provision and placement of wood, straw or coconut fiber mat, synthetic mat, paper mat, jute mesh or other material as a soil retention blanket for erosion control on slopes or ditches or short-term or long-term protection of seeded or sodded areas indicated on the Drawings or as specified by the Engineer or designated representative.

a. Materials

i. Soil Retention Blankets

All soil retention blankets must be listed on TxDOT Approved Products List or approved by the Engineer or designated representative.

The soil retention blanket shall be one (1) of the following classes and types as shown on the Drawings:

A. Class 1. Slope Protection
   1). Type A Slopes 3:1 or flatter - Clay soils
   2). Type B Slopes 3:1 or flatter - Sandy soils
   3). Type C Slopes steeper than 3:1 - Clay soils
   4). Type D Slopes steeper than 3:1 - Sandy soils

B. Class 2. Flexible Channel Liner
   1). Type E Short-term duration (Up to 2 years)
   Shear Stress (t d) < 2.0 pound per square foot [psf]
   2). Type F Short-term duration (Up to 2 years)
   Shear Stress (t d) ≤ 4.0 psf
   3). Type G Long-term duration (Longer than 2 years)
   Shear Stress (t d) ≤ 6.0 psf
   4). Type H Long-term duration (Longer than 2 years)

Shear Stress (t d) ≤ 8.0 psf

ii. Fasteners

The fasteners shall conform to the recommendations of the manufacturer for the selected soil retention blanket.

b. Construction Methods

i. General

The soil retention blanket shall conform to the class and type shown on the Drawings. The Contractor has the option of selecting an approved soil retention blanket conforming to the class and type shown on the Drawings which is included on the Approved Products List published by TxDOT/TTI Hydraulics and Erosion Control Laboratory.

ii. Site Preparation

Prior to placement of the soil retention blanket, the seedbed area to be covered shall be relatively free of all clods and rocks over 1 ½ inches in maximum dimension and all sticks or other foreign matter that will prevent close contact of the preparation mat with the soil surface. The area shall be smooth and free of ruts and other depressions. If the prepared seedbed becomes crusted or eroded as a result of rain or if any eroded places, ruts or depressions exist, the Contractor shall be required to rework the soil until it is smooth and to reseed or re-sod the area at the Contractor's own expense. After the area has been properly prepared, the blanket shall be laid out flat, even and smooth, without stretching or crimping the material.

c. Installation

The Soil Retention Blanket, whether installed as slope protection or as flexible channel liner in accordance with the TxDOT/TTI Approved Products List, shall be placed within 24 hours after seeding (section 710) and/or sodding (section 710) erosion control operations have been completed, or as approved by the Engineer or designated representative. The soil retention blanket shall be installed and anchored in accordance with the Manufacturer's recommendations. The Contractor shall contact the Engineer or designated representative three (3) days prior to the installation of the soil retention blanket to allow for inspection of the installation by City of Copperas Cove personnel.

8. Filter Fabric

a. Materials

i. General

The fabric shall be constructed exclusively of synthetic thermoplastic fibers and may be either woven or non-woven to form a mat of uniform quality. Fabric fibers may be either continuous or discontinuous and oriented in either a random or an aligned pattern throughout the fabric. The fabric shall be mildew resistant, rot proof and shall be satisfactory for use in a wet soil and aggregate environment. The fabric shall contain ultraviolet stabilizers and shall have non-raveling edges.

ii. Physical Requirements

The fabric shall meet the requirements of Table 720H.1, when sampled and tested in accordance with the methods indicated in the table below.

For applications such as water quality facility underdrain wrappings that require a high flow-through rate, or when specified by the engineer, the fabric shall be woven mono-filament and meet the requirements of Table 720H.2.

All material shall be shipped with suitable wrapping to protect the fabric during shipping and storage at the job site.

b. Construction Methods

The submittal requirements shall be completed before any materials are ordered.

The "Filter Fabric" shall be installed in accordance with the manufacturer's recommendations, as indicated on the Drawings or as directed by the Engineer or designated representative. When lapping is required, it shall be in accordance with the manufacturer's recommendations. Backfilling around the Filter Fabric shall be done in such a manner that the Filter Fabric material will not be damaged during the placement.

Table 720H.1 Filter Fabric Requirements		
Original Physical Properties	**Test Method**	**Requirements**
Fabric weight on an ambient temperature air-dried tension free sample, expressed in oz/ sq. yd	TxDOT Tex-616-J*	Slope Stabilization 4.0 minimum
		Gabions and Revet Mattresses 6.0 minimum
Water flow rate by falling head method, 7.9 inches to 3.9 inches on 2-inch ID cylinder with 1-inch diameter orifice, with flow rate expressed in gal/sq. ft/minute	TxDOT Tex-616-J*	80 minimum
Breaking load in either machine or cross-machine direction, expressed in pounds	ASTM D-1682 grab method G**	100 minimum
Equivalent opening size for US Standard sieves.	CW-02215	70 to 100
"Apparent elongation" at breaking load in either machine or cross-machine direction, expressed as percent	ASTM D-1682 grab method G**	100 maximum

* TxDOT Tex-616-J, "Testing of Construction Fibers

** ASTM D 1682 grab method G, "Test Methods for Breaking Load and Elongation of Textile Fabrics"* as modified by TxDOT Test Method Tex-616-J

*** CW-02215, US Army Corps of Engineers, Civil Works Construction Guide Specification "Plastic Filter Fabric".

Table 720H.2: High Flow Filter Fabric Requirements		
Property	**Test Method**	**Requirements**
Fabric Weight	>D 3776	3.0 ounces/square yard minimum
Ultraviolet (UV) Radiation Stability	D 4355	70% strength retained minimum, After 500 hours in xenon arc device
Mullen Burst Strength	D 3786	120 pound per square inch minimum
Water Flow Rate	D 4491	275 gallons/minute/square feet minimum

9. Stabilized Construction Entrance

A Stabilized Construction Entrance is required for sites in which significant truck traffic occurs on a daily basis to avoid getting tracking construction materials onto public roads.

a. Material

i. Stone: Aggregate shall conform to the following gradation when tested using TEX 401-A:

Table 720I.1			
Sieve Size	US 8 inch	US 5 inch	US 2 inch
% Retained per sieve	0	90-100	100

ii. Filter Fabric: A layer of filter fabric shall be installed over the existing grade and underneath stone layer of stabilized construction entrance. The filter fabric will assist in removal of the construction entrance. The filter fabric shall be per the requirements in section 720H "Filter Fabric."

b. Construction Methods

i. Stabilized Construction Entrances are to be constructed such that drainage across the entrance is directed to a controlled, stabilized outlet on site with provisions for storage, proper filtration, and removal of wash water.
ii. The entrance must be sloped away from the paved surface so that storm water is not allowed to leave the site onto roadways.
iii. Minimum width of entrance shall be 15 feet.
iv. Stone shall be placed in a layer of at least 6-inch thickness.
v. Prevent shortcutting of the full length of the construction entrance by installing barriers as necessary.
vi. Vehicles shall not be permitted to track or drop sediment onto paved roads, streets, or parking lots. When necessary, vehicles must be cleaned to remove sediment prior to entrance onto paved areas. When washing is required, it shall be done on a constructed wheel wash facility that drains into an approved sediment trap or sediment basin or other sedimentation/filtration device.
vii. Minimum dimensions for the entrance shall be as follows:

Table 720I.2			
Tract Area	**Average Tract Depth**	**Min. Width of Entrance**	**Min. Depth of Entrance**
< 1 Acre	100 ft.	15 ft.	20 ft.
< 5 Acres	200 ft.	20 ft.	50 ft.
> 5 Acres	> 200 ft.	25 ft.	75-100 ft.

c. Inspection

Stabilized Construction Entrances shall be inspected regularly (at least as often as required by the TPDES Construction General Permit). When sediment has substantially clogged the void area between the rocks, the aggregate mat shall be washed down or replaced. Periodic re-grading and top dressing with additional stone shall be done to keep the efficiency of the entrance from diminishing. If the stabilized construction entrance is not effectively removing sediment from wheels, then a wheel wash shall be implemented.

10. Temporary Grade Stabilization Structure

This item shall govern for construction of a temporary channel lined with Hot Mix Asphaltic Concrete, Portland Cement concrete or comparable non-erodible material. The lining shall be placed

to extend from the top of a slope to the bottom of a slope and to convey surface runoff safely down-slopes without causing erosion. The removal of the entire structure and the revegetation of the area after the permanent facilities are in place shall also be included in this item.

a. Materials
   i. Concrete
      Portland Cement concrete shall conform to Class A, section 200 “Concrete”
   ii. Hot Mix Asphaltic Concrete
      Asphaltic concrete shall conform to section 550 “HMAC.”
   iii. Riprap
      Rock or broken concrete riprap for energy dissipation shall not exceed 5 pounds each and shall conform to section 720F “Riprap.”
   iv. Seeding
      Seeding shall conform to section 710 “Seeding for Erosion Control.”

b. Construction Methods

   The Contractor shall minimize the area disturbed during construction. Prior to placement of the Grade Stabilization Structure, all clearing, grubbing and subgrade preparation operations shall be completed conforming to Items 110 – Right of Way Preparation and 520 – Subgrade.

   Hot Mix Asphaltic Concrete work shall conform to section 550 “HMAC.”

   Concrete work shall conform to section 720F “Riprap” and all applicable concrete requirements of this specification.

   At such time as the structure is no longer needed and with the approval of the Engineer or designated representative, the Contractor shall remove the entire structure and re-vegetate the disturbed area.

11. Mulch Sock

A mulch sock consists of material encased in a tube of mesh. It is used to intercept, settle, and filter sheet flow and pond runoff. Mulch socks provide an environmentally sensitive and cost-effective alternative to sediment fences.

a. Materials
   i. Mulching material can be manufactured on or off the project site and may consist of shredded bark, stump grindings, and/or composted bark
   ii. The mulch shall have the following composition:
      A. Wood chips shall be produced from a 3-inch minus screening process (equivalent to TxDOT item 161, Compost, Section 1.6.2.B Wood Chip Requirements, or latest revision thereof).
   iii. Large portions of silts, clays, or fine sands are not acceptable.
   iv. The pH of the mulch shall be between 5.5 and 8.5.
   v. The organic matter content shall be greater than or equal to 25% on a dry weight basis.
   vi. Mulch material must be free of refuse, physical contaminants, and material toxic to plant growth. It is not acceptable for the mulch material to contain ground construction debris, biosolids, manure, or recyclable material.
   vii. Prior to placement, a representative sample of the mulching material must be certified by the project engineer or his/her designee and accepted by the city inspector.

viii. The sock material mesh opening shall be equal to or less than 3/8 inch and the material tensile strength shall be equal to or greater than 202 psi.

ix. Mulch material must meet requirements in Table 720K.1 below.

Table 720K.1

Item	Requirement	Reference Specification
Particle Size	3" minus screening process	Equivalent to TXDOT item 161, Compost, Section 1.6.2.B, Wood Chip requirements
pH	5.5 - 8.5	TMECC 04. 11-A, "1.5 Slurry pH"
Organic Matter Content	≥25%, dry weight basis	TMECC 05.07-A, "Loss-On-Ignition Organic Matter Method"

b. Construction Methods

i. Install mulch socks in accordance with standard details.

ii. Mulch socks should be used at the base of slopes no steeper than 2:1 and should not exceed the maximum spacing criteria provided in Tables 720K.2.

Table 720K.2

Slope	Max. Slope Length Between Sock (ft)	Max. Drainage Area (sf) per 100 ft of Sock
100:1 - 50:1	100	6,000
50:1 - 30:1	40	4,000
30:1 - 25:1	30	3,000
25:1 - 20:1	25	2,600
20:1 - 10:1	15	1,300
10:1 - 5:1	10	1,000
5:1 - 2:1	5	500

iii. Place mulch socks at a 5 ft or greater distance away from the toe of the slopes to maximize space available for sediment deposition.

iv. When placed on level contours, sheet flow of water should be perpendicular to the mulch sock at impact and unconcentrated.

v. Install mulch socks using rebar (#5 minimum with safety caps) a minimum of 48 inches in length placed on 2-ft centers. In order to prevent the movement or floating of the mulch sock during rain events or construction operations, install steel posts on alternating sides of the sock. Drive the posts into the ground to a minimum depth of 24 inches, leaving less than 12 inches of post above the exposed mulch sock.

vi. In order to prevent water flowing around the ends of the mulch socks, point the ends of the socks up slope.

vii. In order to prevent water from flowing between the gaps at adjacent ends of mulch socks, overlap the ends of adjacent mulch socks a minimum of 12 inches. Never stack mulch socks on top of one another.

viii. Mulch Socks should be placed using 'smiles' and 'j-hooks'. See section 720A "Silt Fence".

ix. For steeper slopes, an additional mulch sock can be constructed on the top of the slope and within the slope area as determined by specific field conditions. Multiple mulch socks are recommended on steeper slopes.

x. Do not use mulch socks in areas of concentrated flow as they are intended to control sheet flow only.

c. Inspection and Maintenance
    i. Inspect mulch socks after installation for gaps under the mulch socks and for gaps between the joints of adjacent ends of mulch socks. Contractor shall repair gaps such that no water flows under or around sock.
    ii. Inspect every seven days and within 24 hours of a rainfall event of 0.5 inches or greater. Replace and repair mulch socks as necessary.
    iii. Sediment retained by the mulch socks shall be removed when it has reached one third of the exposed height of the mulch socks.
    iv. Mulch socks can be vegetated or un-vegetated. Vegetated mulch socks can be left in place. The vegetation will grow in the slope, further anchoring the sock.

12. Payment

Payment for this item(s) shall be subsidiary to either the Stormwater Pollution Prevention Plan (SWPPP) and Implementation or the Erosion Control Plan and Implementation, whichever is used for the project.

STANDARD DETAILS

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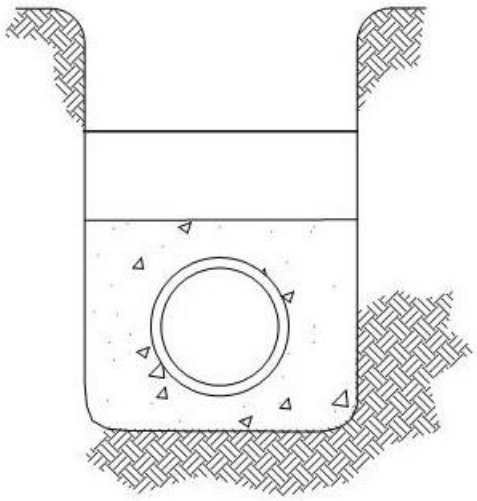
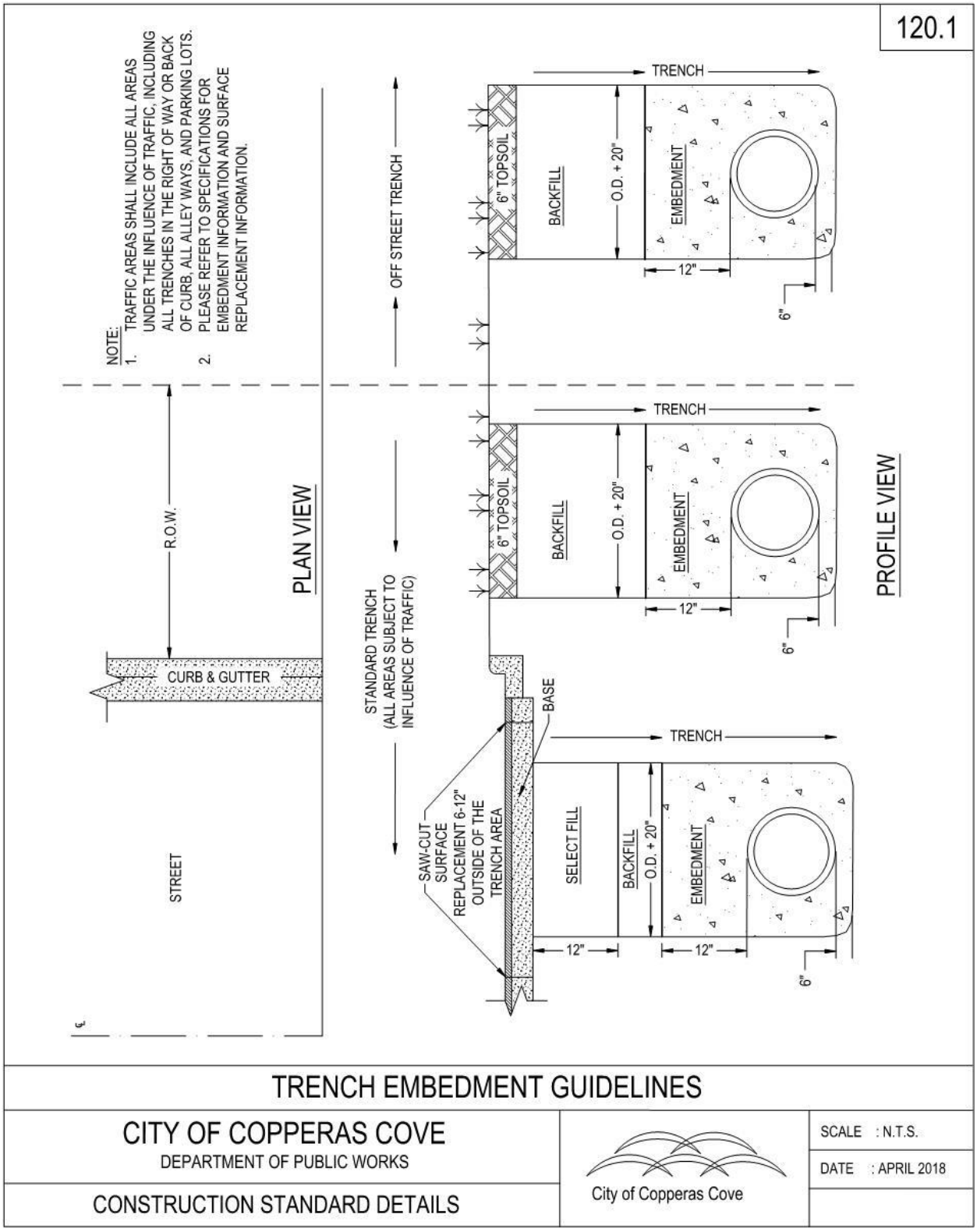
CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

GENERAL DETAILS





TRENCH EMBEDMENT GUIDELINES

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

CONSTRUCTION STANDARD DETAILS

City of Copperas Cove

SCALE : N.T.S.
DATE : APRIL 2018

120.2

EMBEDMENT NOTES

GENERAL

1. GRANULAR EMBEDMENT SHALL BE DEFINED AS:
   A. FREE-FLOWING SAND,
   B. MIXED SAND AND PEA GRAVEL THAT IS FREE OF STONE, ORGANIC MATERIAL OR CLAY AND WHICH MATERIAL SHALL NOT FORM MUD OR MUCK WHEN WET. THIS MATERIAL MAY BE AN INFERIOR GRADE OR "PIT-RUN" SAND NOT NORMALLY CONSIDERED SATISFACTORY FOR CONSTRUCTION PURPOSES, AND IT MAY BE USED DIRECTLY FROM PITS WITHOUT PROCESSING,
   C. CRUSHED STONE NO LARGER THAN 5/8 OF AN INCH IN DIAMETER
2. NO FINE GRANULAR MATERIAL WILL BE INSTALLED BY THE CONTRACTOR WITHOUT THE ENGINEER'S APPROVAL

EMBEDMENT FOR WATERLINES

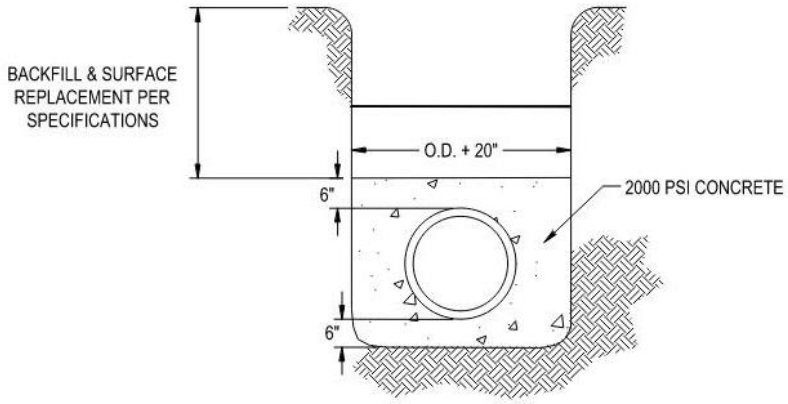
1. EMBEDMENT FOR WATERLINES SHALL BE SAND AS DEFINED ABOVE.
2. ALTERNATE EMBEDMENT MATERIALS WILL REQUIRE A MATERIAL SUBMISSION TO THE CITY ENGINEER AND WATER SUPERINTENDENT FOR APPROVAL. ALTERNATE EMBEDMENT MATERIALS SHOULD ONLY BE CONSIDERED IF FREE-FLOWING SAND IS UNAVAILABLE.
3. ALTERNATE EMBEDMENT MATERIALS ARE:
   A. MANUFACTURED SAND,
   B. PEA GRAVEL
   C. SELECT FILL

EMBEDMENT FOR SANITARY SEWER LINES

1. EMBEDMENT FOR SANITARY SEWER LINES SHALL BE EITHER PEA GRAVEL AS DEFINED ABOVE OR CRUSHED STONE NO LARGER THAN 5/8-INCH IN DIAMETER.

EMBEDMENT NOTES		
CITY OF COPPERAS COVE DEPARTMENT OF PUBLIC WORKS	City of Copperas Cove	SCALE : N.T.S.
CONSTRUCTION STANDARD DETAILS		DATE : OCTOBER 2022

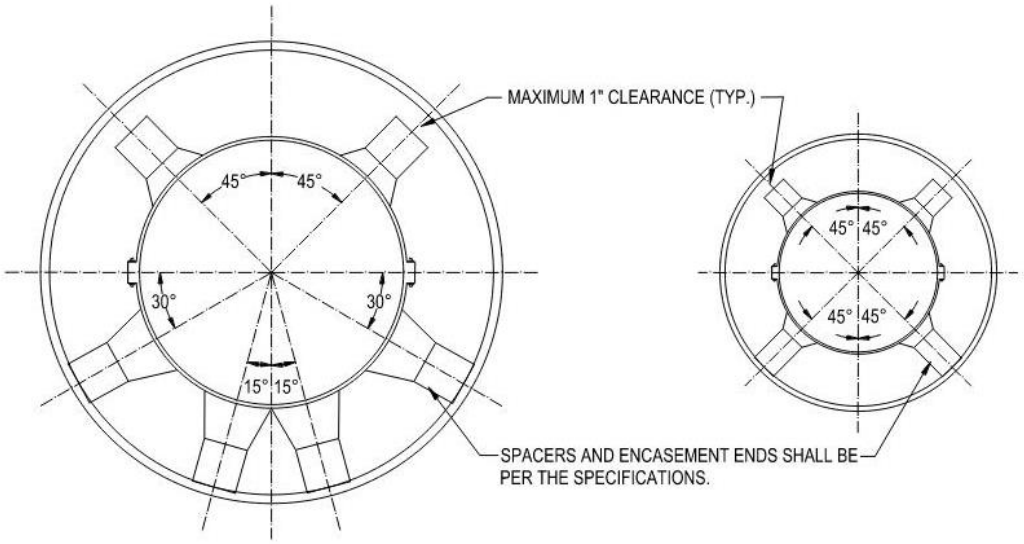
120.3



CONCRETE ENCASEMENT

CONCRETE ENCASEMENT		
CITY OF COPPERAS COVE DEPARTMENT OF PUBLIC WORKS	City of Copperas Cove	SCALE : N.T.S. DATE : APRIL 2018
CONSTRUCTION STANDARD DETAILS		

130.1



SIZES 14" THRU 36"

SIZES 4" THRU 12"

REQUIRED INSTALLATION PRACTICES FOR PIPE IN CASINGS ARE:

1. BELL MUST MAINTAIN A MINIMUM OF 1" CLEARANCE FROM CASING WALL.
2. THE PIPE MUST BE BRACED AND ANCHORED IN A MANNER THAT PREVENTS MOVEMENT IN ANY DIRECTION.
3. THE PIPE MUST BE INSTALLED IN A MANNER THAT WILL PERMIT ITS REMOVAL WITH REASONABLE EASE, SHOULD THIS BE NECESSARY AT A LATER DATE.
4. PLACE SPACERS AT NO MORE THAN 2' FROM EACH JOINT AND A MAXIMUM SPACING AS PER MANUFACTURER'S RECOMMENDATION.
5. SPACERS MUST BE A MAXIMUM OF 1" FROM CASING WALL.
6. ALL CASINGS EXPOSED TO THE ATMOSPHERE MUST BE PAINTED PER STANDARD SPECIFICATIONS.
7. FOR RAILROAD CROSSING, COORDINATE WITH TEXAS DEPARTMENT OF TRANSPORTATION (TXDOT) RAIL DIVISION FOR REQUIRED THICKNESS OF CASING PIPE.

PIPE THROUGH CASING

CITY OF COPPERAS COVE DEPARTMENT OF PUBLIC WORKS	City of Copperas Cove	SCALE : N.T.S.
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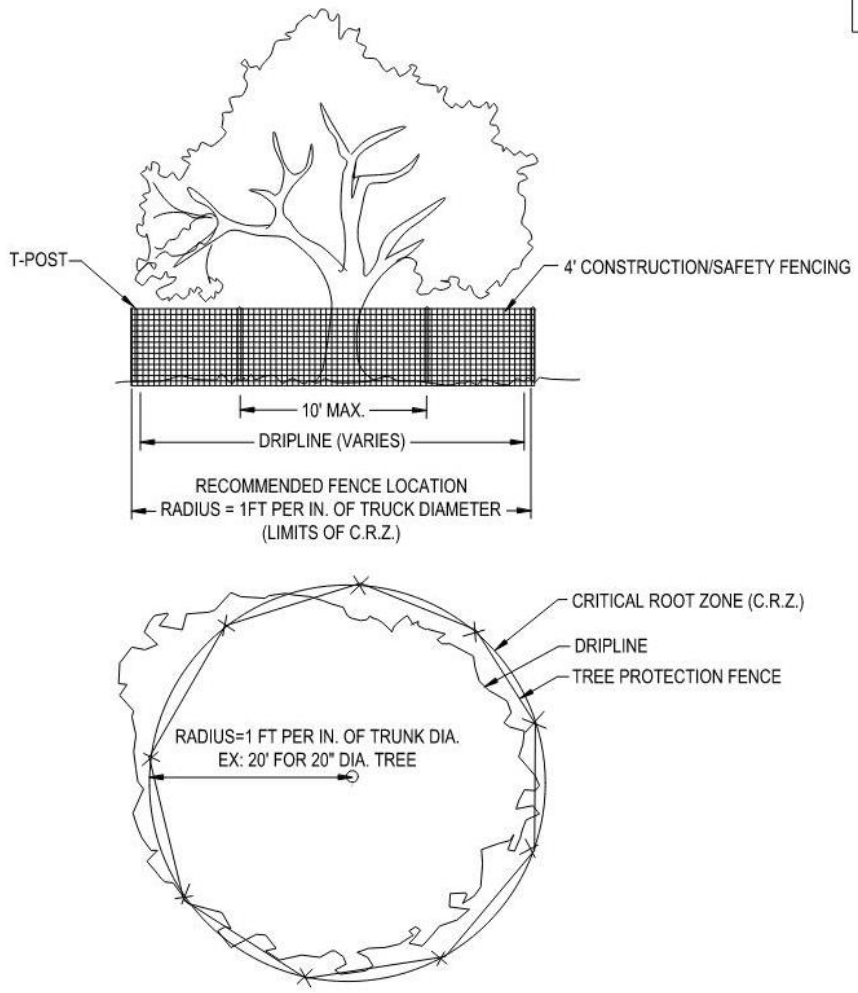
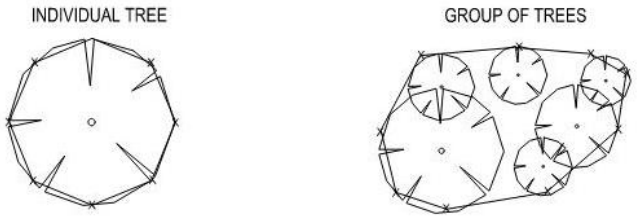
160.1





FENCE LOCATION FOR INDIVIDUAL TREE AND GROUP OF TREES

TREE PROTECTION FENCING

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

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City of Copperas Cove

SCALE : N.T.S.
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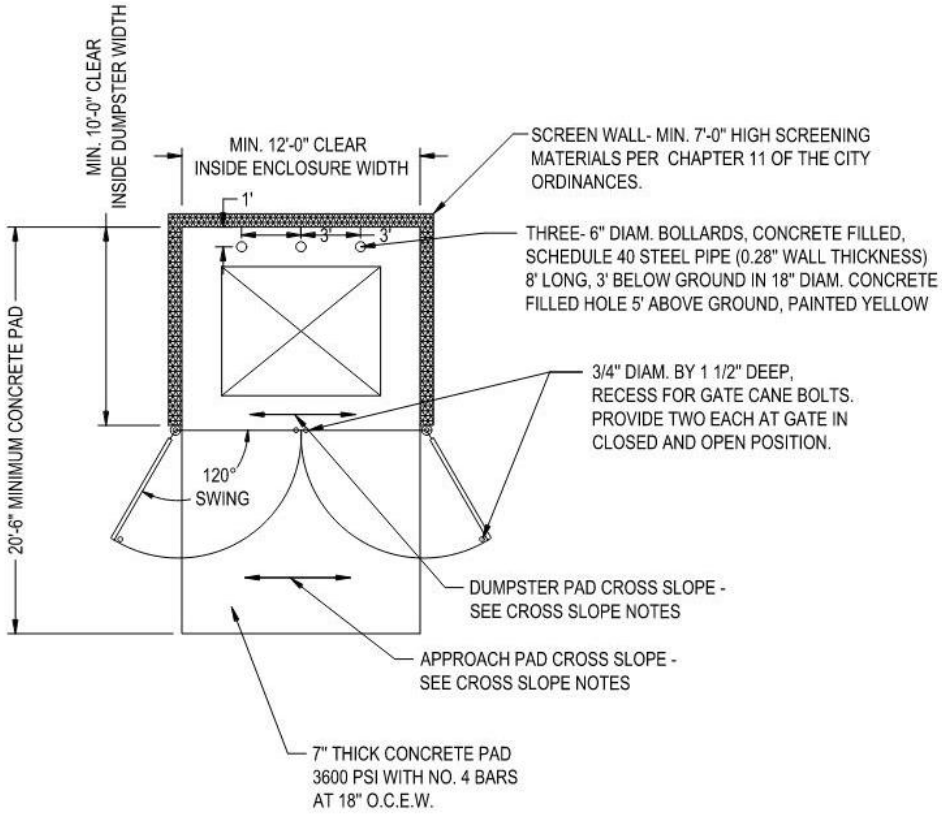
180.1



CROSS SLOPE NOTES:

1. THE MAXIMUM CROSS SLOPE FOR THE CONCRETE APPROACH AND DUMPSTER PAD SHALL BE 2%, UNLESS SITE AND TOPOGRAPHY LIMITATIONS NECESSITATE THE USE OF A STEEPER SLOPE. A STEEPER SLOPE WILL REQUIRE THE APPROVAL OF THE PUBLIC WORKS DIRECTOR. IN NO CASE SHALL THE CROSS SLOPE EXCEED 5%.
2. IF THE CROSS SLOPES OF THE DUMPSTER PAD AND APPROACH PAD ARE DIFFERENT, THE DIFFERENCE BETWEEN THE TWO SLOPES SHALL BE A MAXIMUM OF 2%.

SOLID WASTE CONTAINER PAD DETAIL

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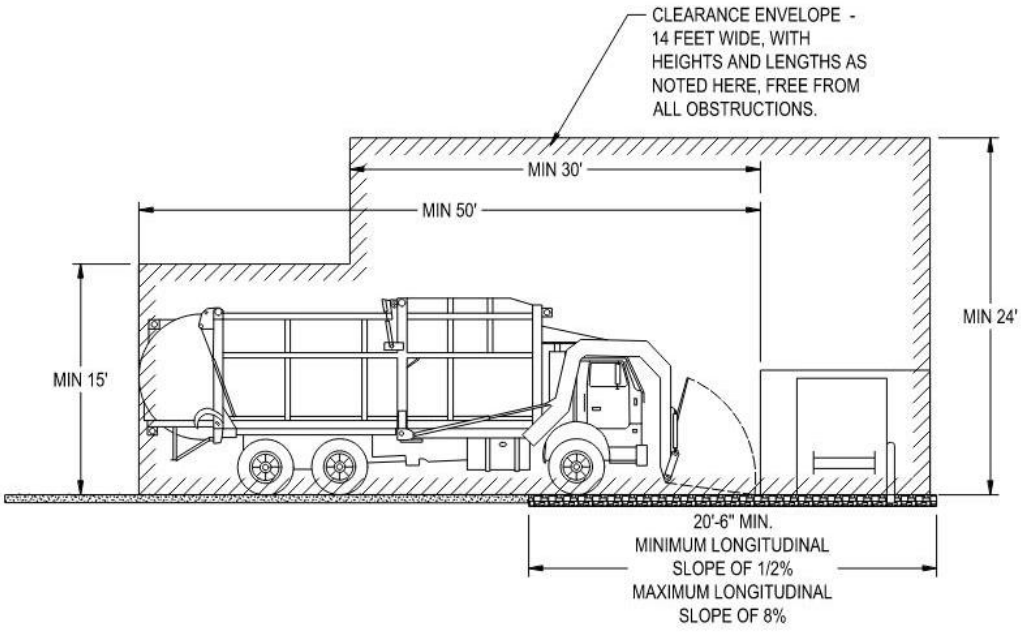
180.2



SOLID WASTE CONTAINER FRONT-LOADER VEHICLE ACCESS

CITY OF COPPERAS COVE
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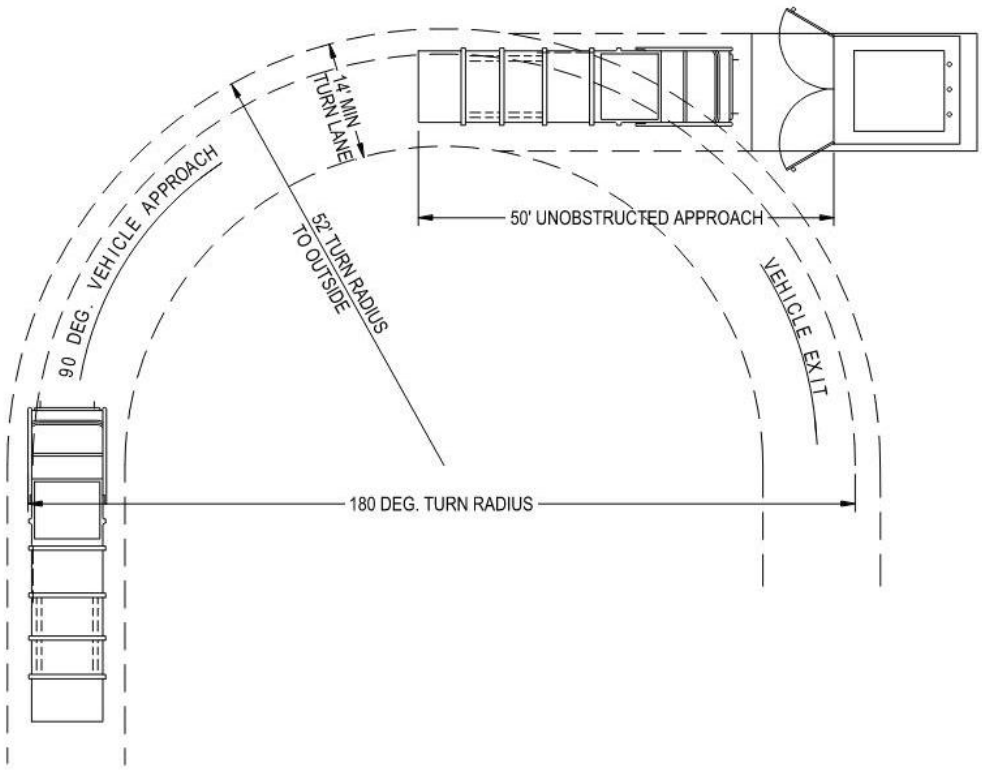
180.3



NOTE:
ALTERNATE DESIGN ALLOWED ONLY WHEN PROVEN THROUGH ACCEPTED ENGINEERING ANALYSIS (I.E. AUTOTURN DATA OR SIMILAR ENGINEERING ANALYSIS SOFTWARE)

SOLID WASTE CONTAINER VEHICLE ACCESS DETAIL

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

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City of Copperas Cove

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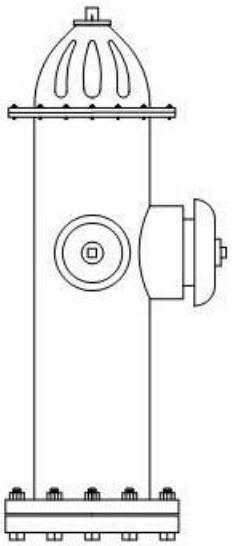
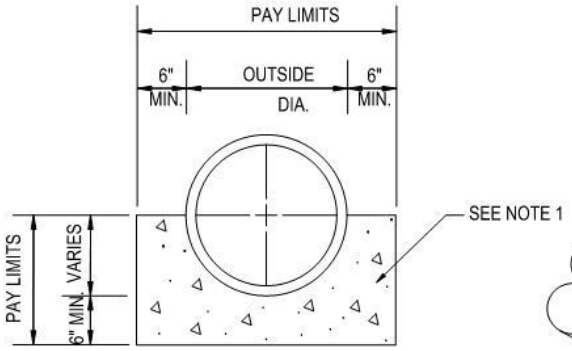
CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

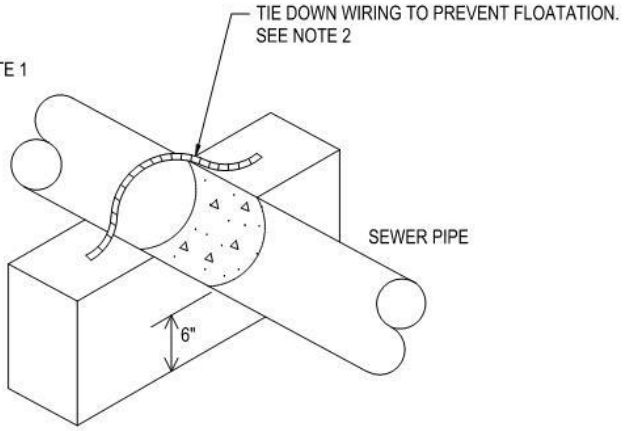
WATER DETAILS



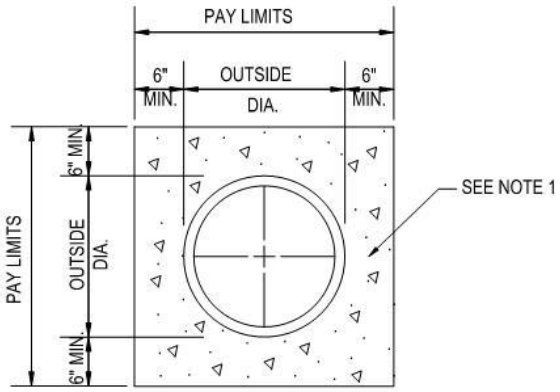
210.1



TYPICAL CONCRETE CRADLE



TYPICAL SUPPORT FOR CRADLE



TYPICAL CONCRETE ENCASEMENT

NOTE:
1. ALL CONCRETE ENCASEMENT SHALL BE POURED AT A PLANE 6" ABOVE THE PIPE BETWEEN EXCAVATED TRENCH WALLS.
2. FOR PRECAST CRADLE, TIE DOWN WIRE SHALL BE IN ACCORDANCE WITH MANUFACTURER RECOMMENDED PRACTICE. FOR CAST IN PLACE CRADLE, USE J-HOOK OR OTHER APPROVED METHOD TO ATTACH TIE DOWN WIRE.
3. METAL FORM TIES SHALL BE PER SPECIFICATION 200.
4. CONCRETE FOR CRADLE SUPPORT SHALL BE PER SPECIFICATION 210.

TYPICAL CONCRETE ENCASEMENT AND CRADLE

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

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City of Copperas Cove

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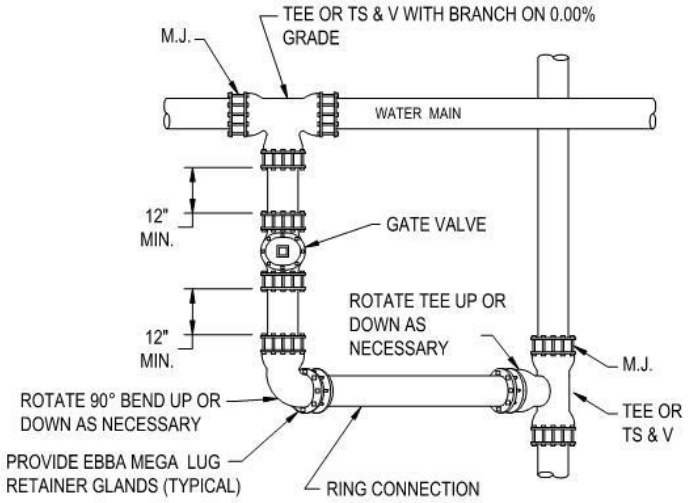
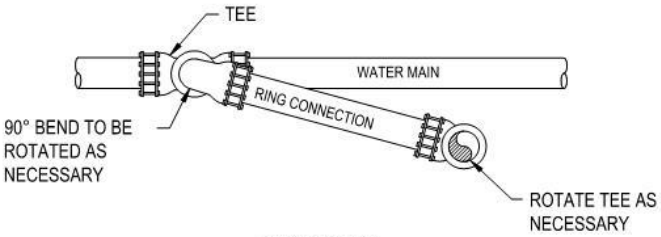
311.1



PLAN



SECTION

NOTES:
1. MINIMUM DIAMETER OF RING CONNECTION SHALL BE DIAMETER OF AS SMALLER MAIN.
2. IF TAPPING SLEEVE & VALVE IS USED, GATE VALVE IS NOT NECESSARY.
3. WATER MAIN MAY GO OVER OR UNDER AS NECESSARY.

RING CONNECTION

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City of Copperas Cove

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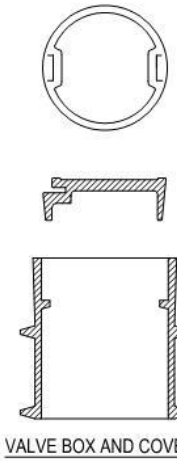
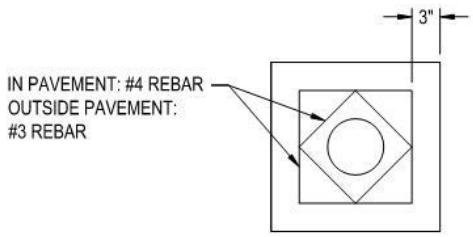
311.2



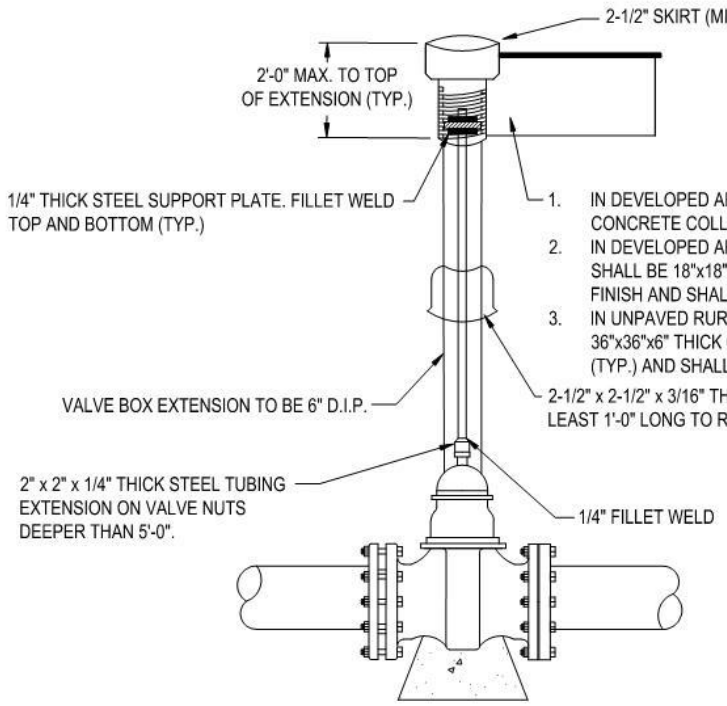
SEE CITY OF COPPERAS COVE SPECIFICATIONS, 311.B.A FOR APPROVED MANUFACTURERS FOR VALVE BOX AND COVER .

VALVE BOX AND COVER



VALVE BOX PLAN VIEW

NOTE: CIRCULAR FORMS WILL ALSO BE ALLOWED



1. IN DEVELOPED AREAS, IN PAVEMENT, NO CONCRETE COLLAR WILL BE REQUIRED.
2. IN DEVELOPED AREAS, OUT OF PAVEMENT, SLABS SHALL BE 18"x18"x6" THICK CONCRETE W/ BROOM FINISH AND SHALL BE PLACED TO GRADE.
3. IN UNPAVED RURAL AREAS, SLABS SHALL BE 36"x36"x6" THICK CONCRETE W/ BROOM FINISH (TYP.) AND SHALL BE PLACED TO GRADE.

VALVE BOX & EXTENSION

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

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City of Copperas Cove

SCALE : N.T.S.

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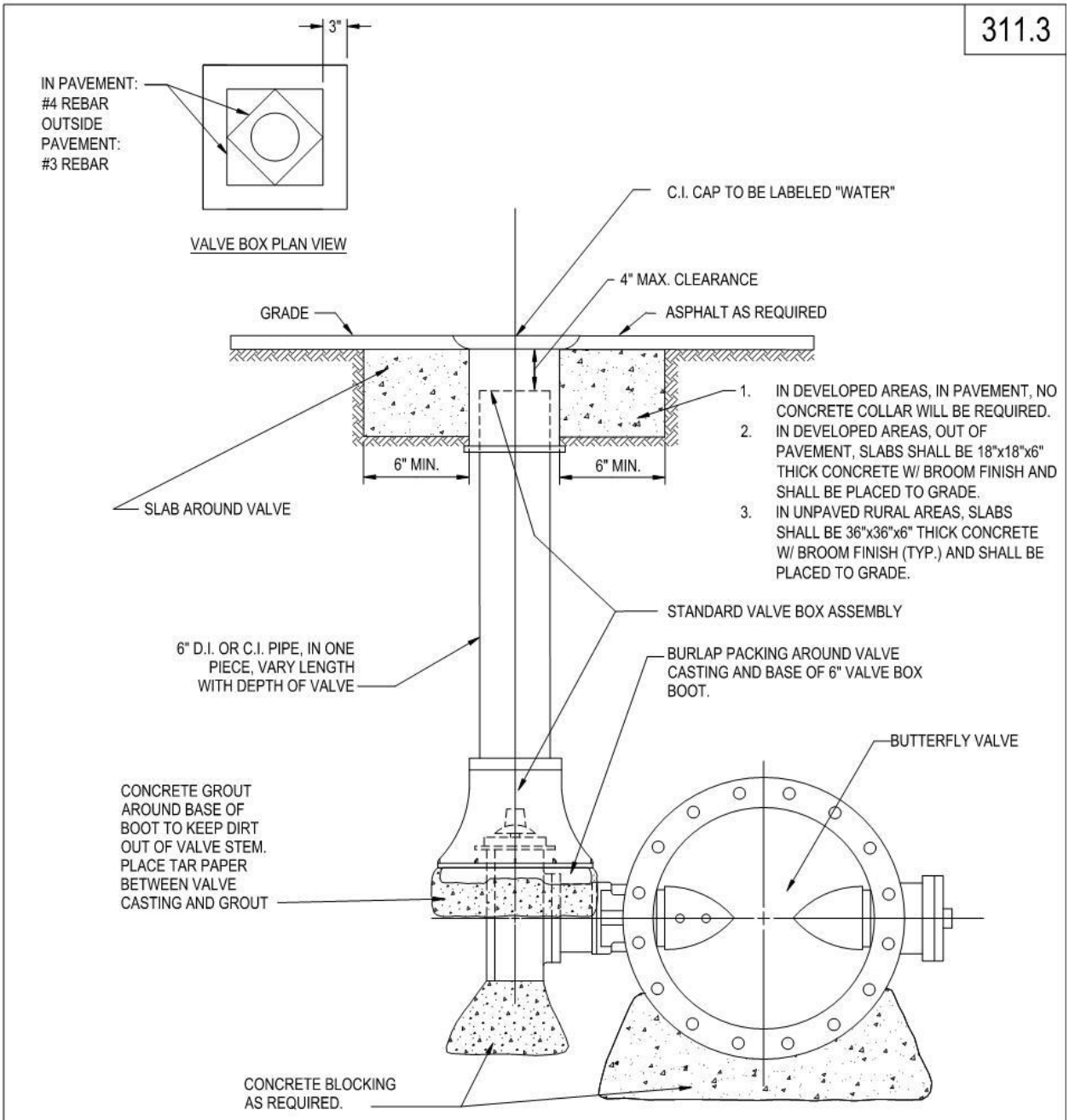
311.3



BUTTERFLY VALVE AND VALVE BOX - FOR HORIZONTAL GEARBOX

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

CONSTRUCTION STANDARD DETAILS

City of Copperas Cove

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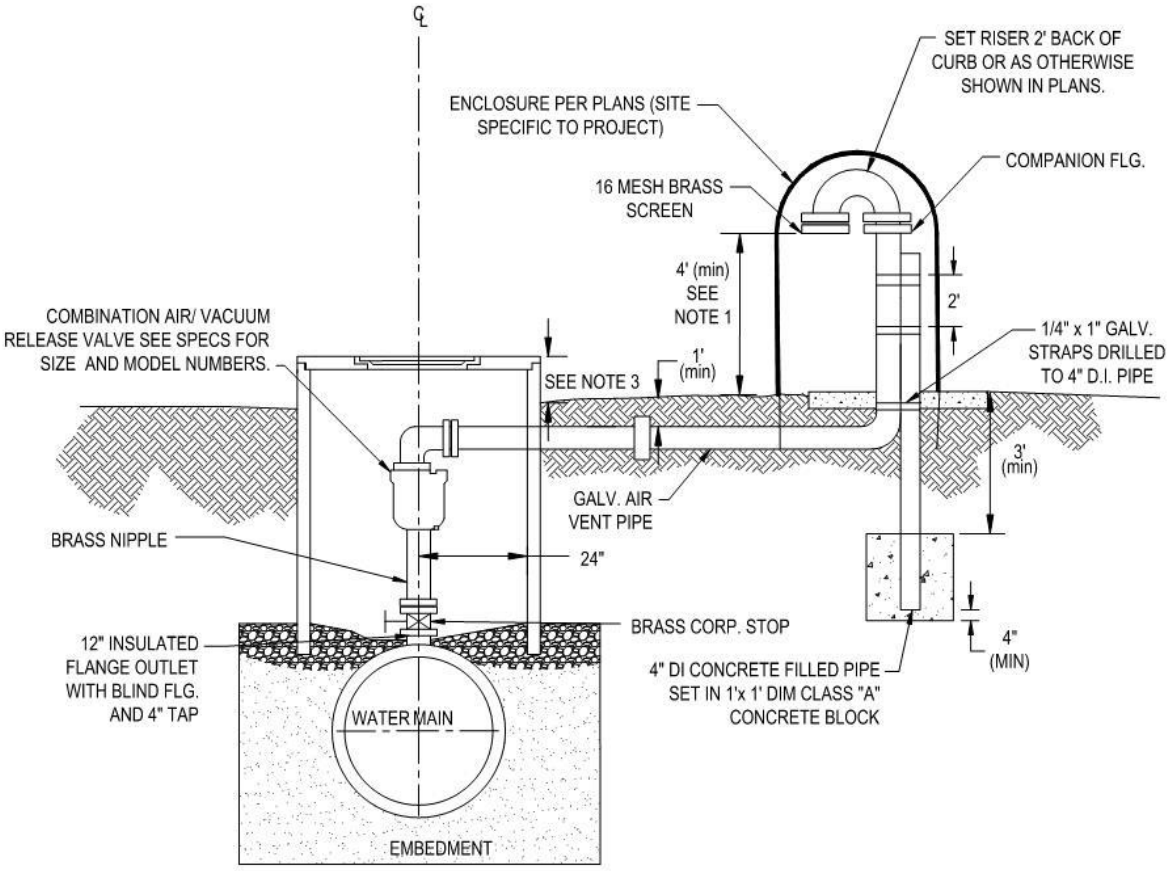
311.4



NOTES:
1. TCEQ REQUIREMENTS FOR 100-YEAR FLOOD PLAIN.
2. AIR RELEASE VALVE ENCLOSURE CAN BE 4' DIAMETER MANHOLE OR APPROPRIATELY SIZED VAULT THAT MEETS TRAFFIC LOADING REQUIREMENTS FOR AREAS WHERE AIR RELEASE VALVE IS IN THE RIGHT OF WAY.
3. 1'-0" FOR AREAS OUTSIDE OF RIGHT OF WAY

STANDARD AIR RELEASE VALVE FOR WATER MAIN VENT

CITY OF COPPERAS COVE
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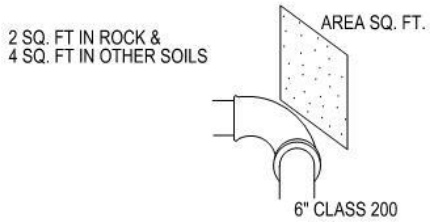
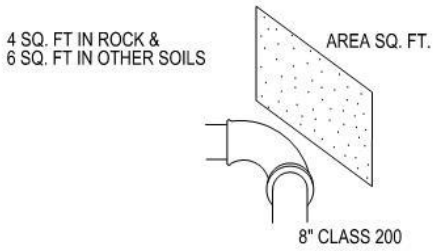
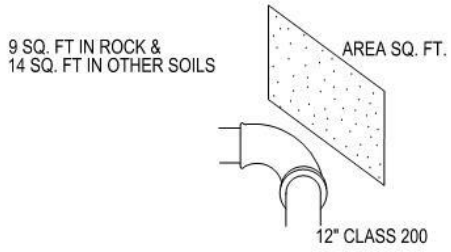
312.1

TYPICAL BLOCKING FOR 90° BENDS:

AREA IN SQ. FT. FOR EACH OF THE FOLLOWING PIPE SIZES:







THRUST BLOCKING DESIGN

ON BASIS OF 200 P.S.I. WATER PRESSURE USED FOR TESTS, THE BLOCKING REQUIRED FOR TWO TYPES OF SOILS IS NOTED BELOW. IN ONE CASE, A SOIL PRESSURE OF 5000 P.S.F. IS USED FOR ROCK EXCAVATION AND FOR SOILS OTHER THAN ROCK A 3000 P.S.F. BEARING SOIL PRESSURE IS USED. THE SURFACE AREAS BELOW ARE FOR UNDISTURBED SOIL OR ROCK.

THE DISTRIBUTION ON SYSTEM IS DESIGNED TO OPERATE WITH A MAXIMUM WATER PRESSURE OF 175 P.S.I. ALL CALCULATIONS APPLY TO DUCTILE IRON PIPE AND P.V.C. PIPE CLASS 200 (SDR 13.5).

SQUARE FEET 0F BLOCKING REQUIRED FOR ROCK EXCAVATION

SIZE PIPE	TEES & DEAD ENDS	90° BENDS	45° BENDS	22 1/2° BENDS
6"	2	2	1	1
8"	3	4	2	1
12"	6	9	5	2
16"	11	15	8	4

SQUARE FEET 0F BLOCKING REQUIRED FOR OTHER THAN ROCK EXCAVATION

SIZE PIPE	TEES & DEAD ENDS	90° BENDS	45° BENDS	22 1/2° BENDS
6"	3	4	2	1
8"	4	6	4	2
12"	10	14	8	4
16"	18	25	14	7

1. TRANSIT 2000 P.S.I. CONCRETE MIX SHALL BE USED; HOWEVER FOR SMALL VOLUME REQUIREMENTS CON- CRETE MIXED AT JOB SITE WILL BE ACCEPTABLE.
2. ONLY IF A CONCRETE MIXER IS USED, ALL AGGREGATE SHALL BE CLEAN AND THE FIELD MIX SHALL BE IN THE RATIO OF 1:3:4 AND CONTAIN NOT LESS THAN 4 SACKS OF CEMENT PER CU. YD.

THRUST BLOCKING

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

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City of Copperas Cove

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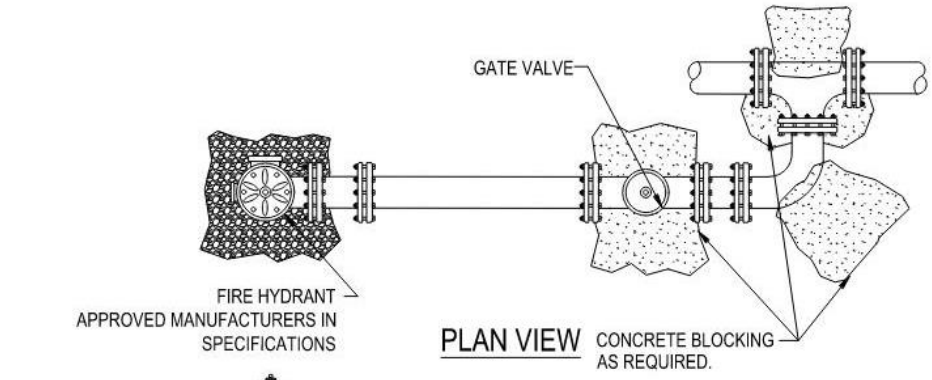
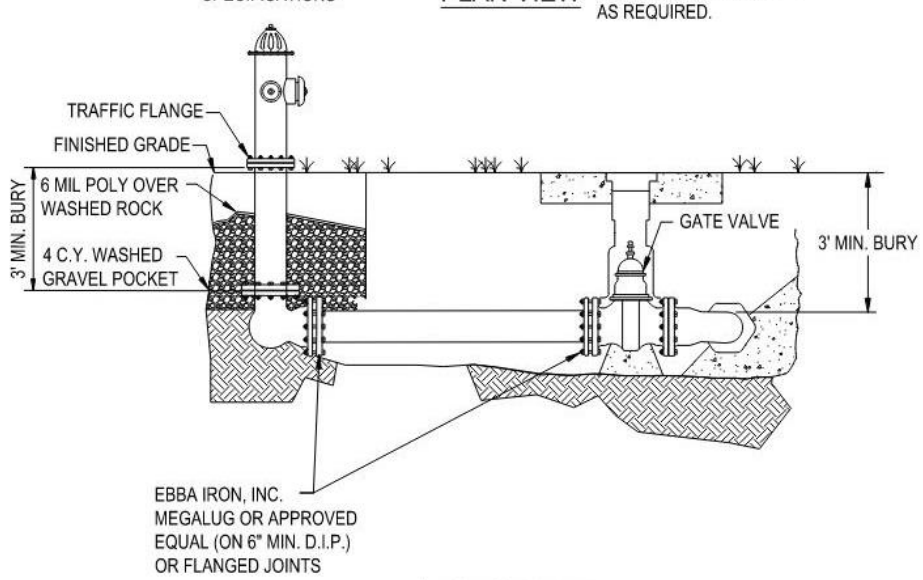
320.1



PLAN VIEW



SECTION VIEW

NOTES:
1. FIRE HYDRANT TO BE INSTALLED ACCORDING TO MANUFACTURER'S SPECIFICATIONS. CONTRACTOR TO REMOVE CHAINS FROM F.H. CAPS.
2. VALVE IS REQUIRED TO BE POSITIONED AS CLOSE TO TEE AS POSSIBLE.
3. ON OPEN DITCH STREET, FIRE HYDRANT SHALL BE PLACED ON THE TOP BANK OPPOSITE OF THE DITCH FROM THE STREET.
4. ALL FITTINGS ON FIRE HYDRANT LEAD NEED TO BE EBBA IRON, INC. MEGALUG RETAINER GLANDS OR APPROVED EQUAL OR FLANGED JOINTS.
5. LEAD SHALL BE D.I.P. IN ALL CASES, SHALL BE 6" MIN. AND SHALL BE POLY WRAPPED.

FIRE HYDRANT SETTING - PARALLEL TO MAIN

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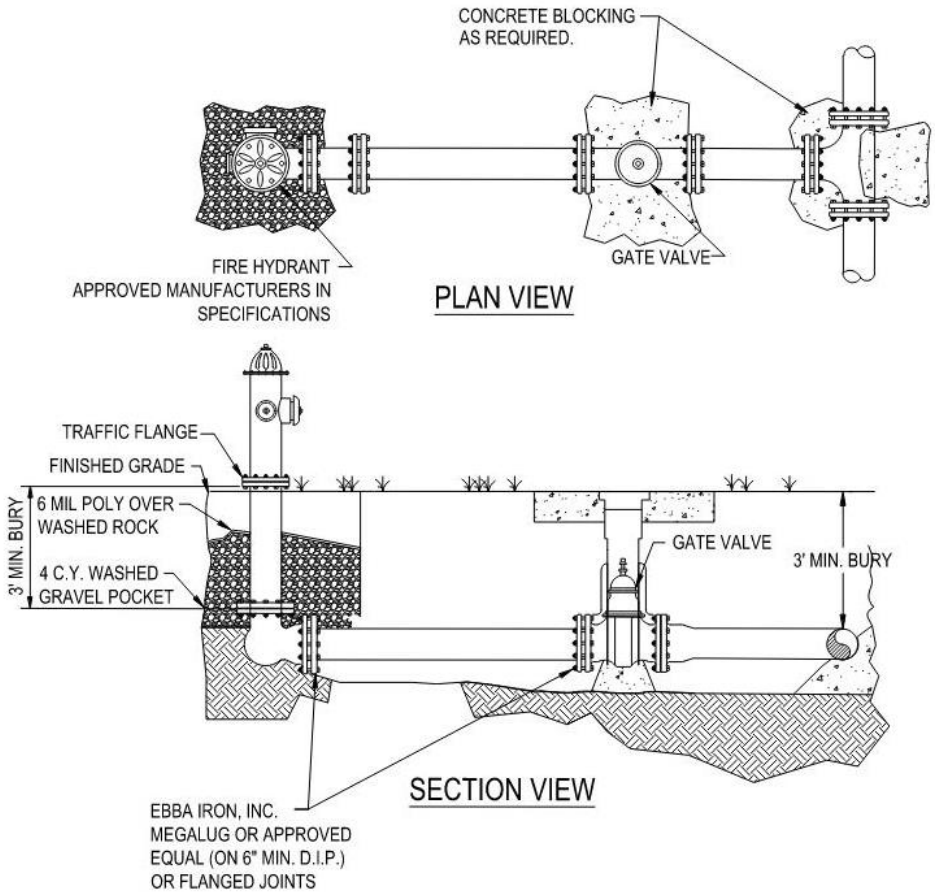
320.2



NOTES:

1. FIRE HYDRANT TO BE INSTALLED ACCORDING TO MANUFACTURER'S SPECIFICATIONS. CONTRACTOR TO REMOVE CHAINS FROM F.H. CAPS.
2. VALVE IS REQUIRED TO BE POSITIONED AS CLOSE TO TEE AS POSSIBLE.
3. ON OPEN DITCH STREET, FIRE HYDRANT SHALL BE PLACED ON THE TOP BANK OPPOSITE OF THE DITCH FROM THE STREET.
4. ALL FITTINGS ON FIRE HYDRANT LEAD NEED TO BE EBBA IRON, INC. MEGALUG RETAINER GLANDS OR APPROVED EQUAL OR FLANGED JOINTS.
5. LEAD SHALL BE D.I.P. IN ALL CASES, SHALL BE 6" MIN. AND SHALL BE POLY WRAPPED.

FIRE HYDRANT SETTING - PERPENDICULAR TO MAIN

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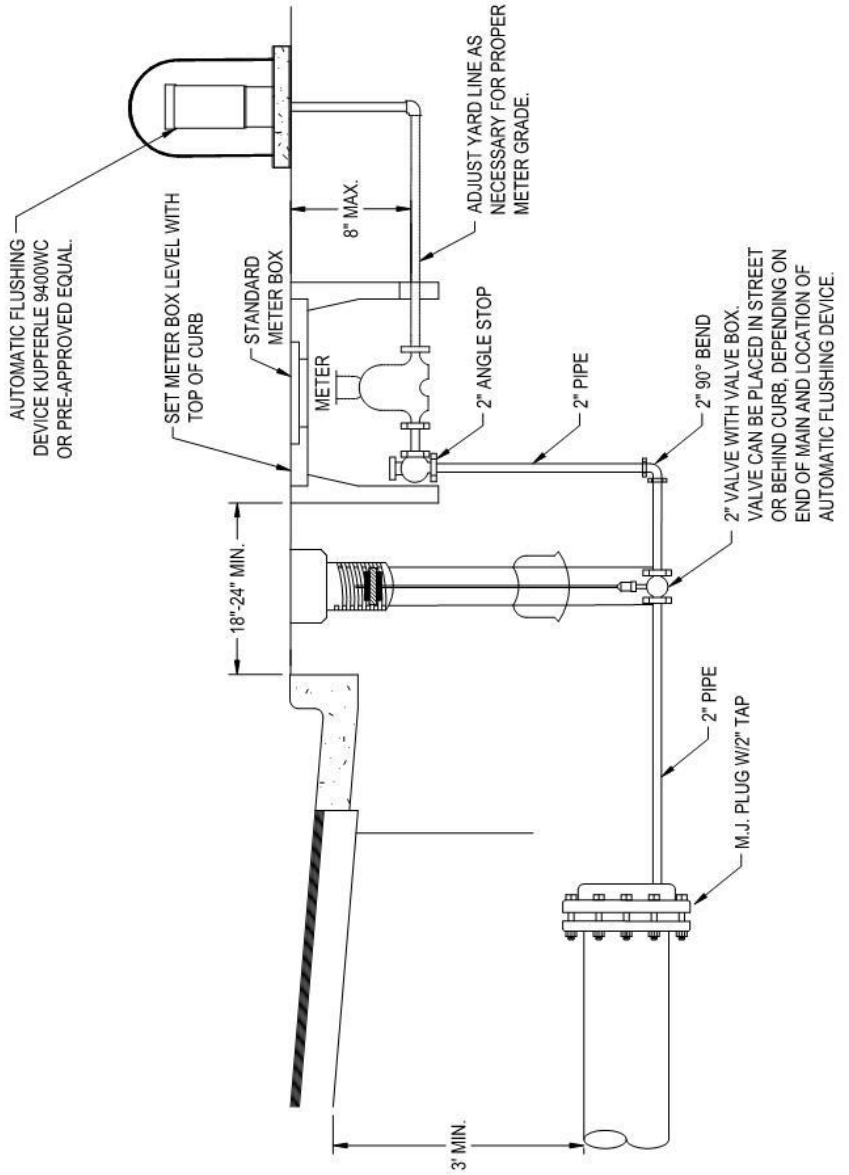
320.3



NOTES:

1. ALL FITTINGS SHALL BE COPPER COMPRESSION FITTINGS.
2. EROSION CONTROL AND AREA DRAINAGE MEASURES AT FLUSHING VALVE DISCHARGE MUST BE INSTALLED TO MEET SITE CONDITIONS.
3. DISCHARGE OF CHLORINATED WATER MUST COMPLY WITH TCEQ REQUIREMENTS.
4. THE METER IS TO BE LOCATED AS CLOSE TO THE MAIN AS POSSIBLE (MIN. 2'-0" CLEARANCE). LOCATIONS SHOULD BE REVIEWED BY THE INSPECTOR. VARIATIONS WILL BE APPROVED ON A CASE BY CASE BASIS ONLY.

DEAD END WATER MAIN AUTOMATIC FLUSHING VALVE

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

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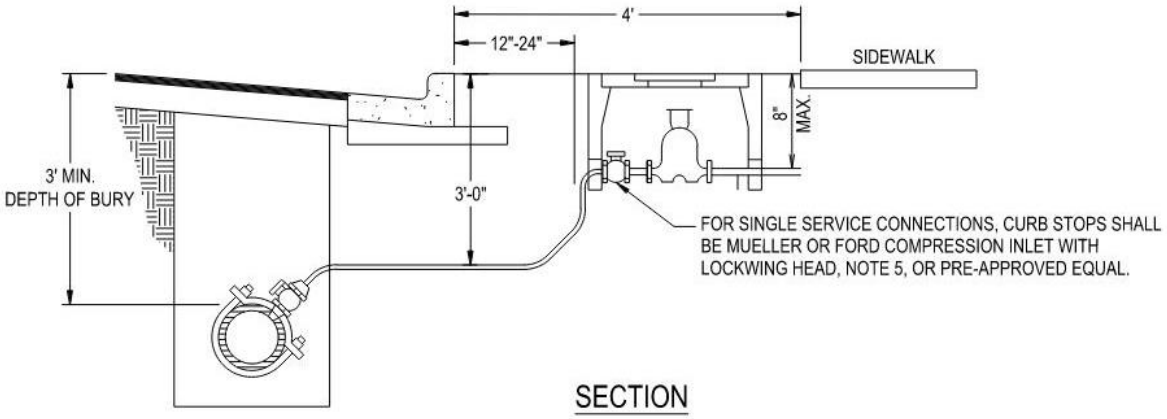
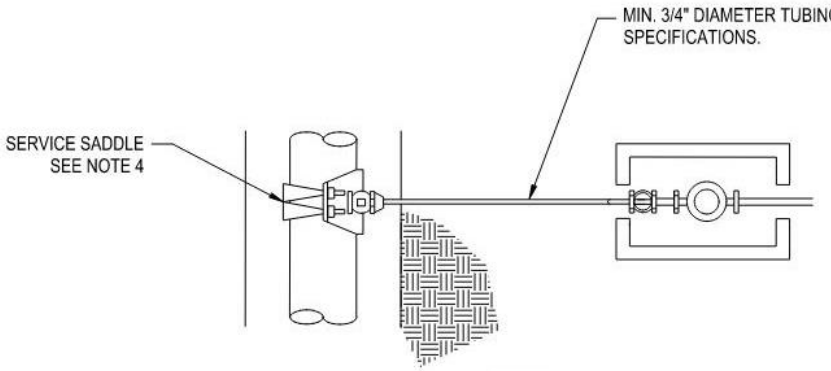
330.1 A



SECTION



PLAN

NOTES:

1. METERS 3" AND LARGER WILL BE INSTALLED IN A CONCRETE VAULT.
2. THE METER IS TO BE LOCATED AS CLOSE TO THE MAIN AS POSSIBLE. (MIN. 2'-0" CLEARANCE). LOCATIONS SHOULD BE REVIEWED BY THE CITY INSPECTOR. VARIATIONS MAY BE APPROVED ON A CASE BY CASE BASIS ONLY.
3. FITTINGS FOR COPPER TUBING OR POLYETHYLENE TUBING SHALL BE BRASS AND COMPRESSION TYPE.
4. SERVICE SADDLE FOR C.I.P., D.I.P, OR A.C. PIPE SHALL BE SMITH BLAIR 313 OR FORD F202. SERVICE SADDLE FOR P.V.C PIPE SHALL BE SMITH BLAIR 317.
5. CURB STOP MUST HAVE A PLACE TO LOCK A PADLOCK WHEN ISOLATING THE LINE FOR SERVICE.
6. LOCATION OF METER BOX AND METER DIFFERENT THAN THESE REQUIREMENTS REQUIRES THE APPROVAL OF THE WATER DISTRIBUTION SUPERINTENDENT. APPROVED SIGNIFICANT FIELD ADJUSTMENTS MADE AS PART OF A DEVELOPMENT ARE TO BE NOTED IN THE AS-BUILTS SUBMITTED TO THE CITY.

TYPICAL SINGLE METER SERVICE CONNECTION (IN STREET)

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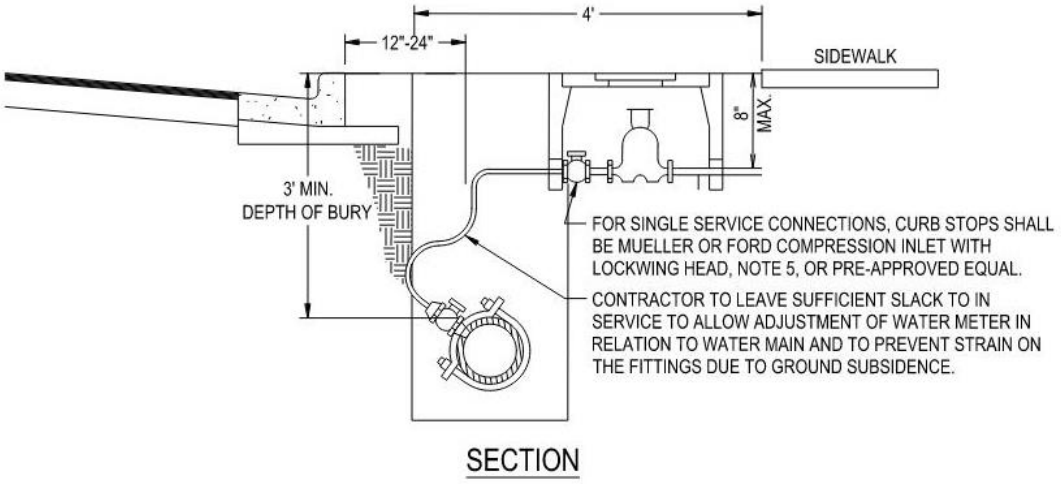
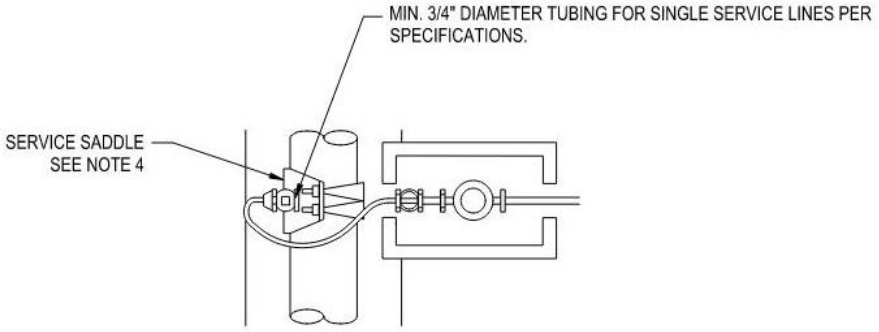
330.1 B



SECTION



PLAN

NOTES:

1. METERS 3" AND LARGER WILL BE INSTALLED IN A CONCRETE VAULT.
2. THE METER IS TO BE LOCATED AS CLOSE TO THE MAIN AS POSSIBLE. (MIN. 2'-0" CLEARANCE). LOCATIONS SHOULD BE REVIEWED BY THE CITY INSPECTOR. VARIATIONS MAY BE APPROVED ON A CASE BY CASE BASIS ONLY.
3. FITTINGS FOR COPPER TUBING OR POLYETHYLENE TUBING SHALL BE BRASS AND COMPRESSION TYPE.
4. SERVICE SADDLE FOR C.I.P., D.I.P, OR A.C. PIPE SHALL BE SMITH BLAIR 313 OR FORD F202. SERVICE SADDLE FOR P.V.C PIPE SHALL BE SMITH BLAIR 317.
5. CURB STOP MUST HAVE A PLACE TO LOCK A PADLOCK WHEN ISOLATING THE LINE FOR SERVICE.
6. LOCATION OF METER BOX AND METER DIFFERENT THAN THESE REQUIREMENTS REQUIRES THE APPROVAL OF THE WATER DISTRIBUTION SUPERINTENDENT. APPROVED SIGNIFICANT FIELD ADJUSTMENTS MADE AS PART OF A DEVELOPMENT ARE TO BE NOTED IN THE AS-BUILTS SUBMITTED TO THE CITY.

TYPICAL SINGLE METER SERVICE CONNECTION (OUTSIDE OF STREET)

CITY OF COPPERAS COVE DEPARTMENT OF PUBLIC WORKS	City of Copperas Cove	SCALE : N.T.S.
		DATE : OCTOBER 2022
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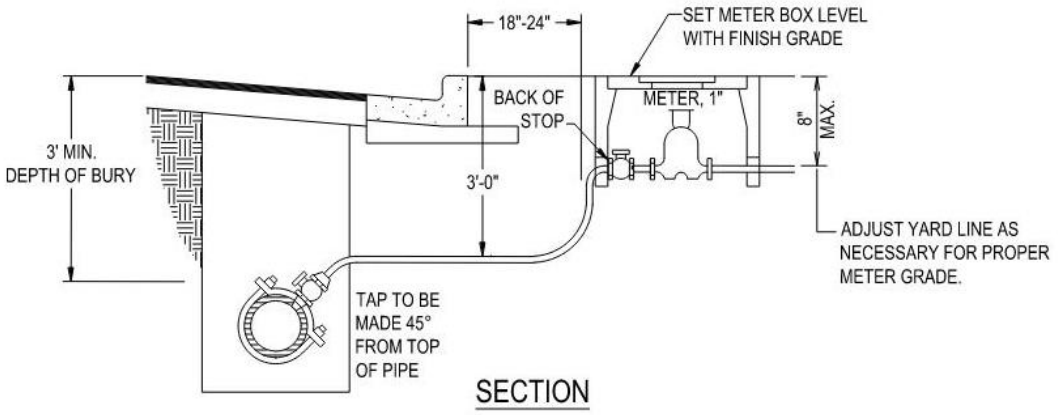
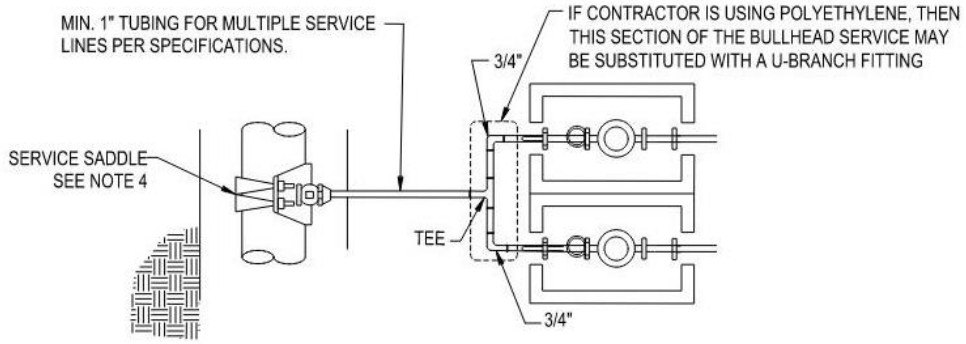
330.2 A



SECTION



PLAN

NOTES:

1. METERS 3" AND LARGER WILL BE INSTALLED IN A CONCRETE VAULT.
2. THE METER IS TO BE LOCATED AS CLOSE TO THE MAIN AS POSSIBLE. (MIN. 2'-0" CLEARANCE). LOCATIONS SHOULD BE REVIEWED BY THE CITY INSPECTOR. VARIATIONS MAY BE APPROVED ON A CASE BY CASE BASIS ONLY.
3. FITTINGS SHALL BE BRASS AND COMPRESSION TYPE.
4. SERVICE SADDLE FOR C.I.P., D.I.P, OR A.C. PIPE SHALL BE SMITH BLAIR 313 OR FORD F202. SERVICE SADDLE FOR P.V.C PIPE SHALL BE SMITH BLAIR 317.
5. WHERE BOX IS EXPOSED TO TRAFFIC, USE CONCRETE BOX WITH CASE IRON TRAFFIC COVER WITH CAST IRON READER LID.
6. LOCATION OF METER BOX AND METER DIFFERENT THAN THESE REQUIREMENTS REQUIRES THE APPROVAL OF THE WATER DISTRIBUTION SUPERINTENDENT. APPROVED SIGNIFICANT FIELD ADJUSTMENTS MADE AS PART OF A DEVELOPMENT ARE TO BE NOTED IN THE AS-BUILTS SUBMITTED TO THE CITY.

BULLHEAD METER (IN STREET)

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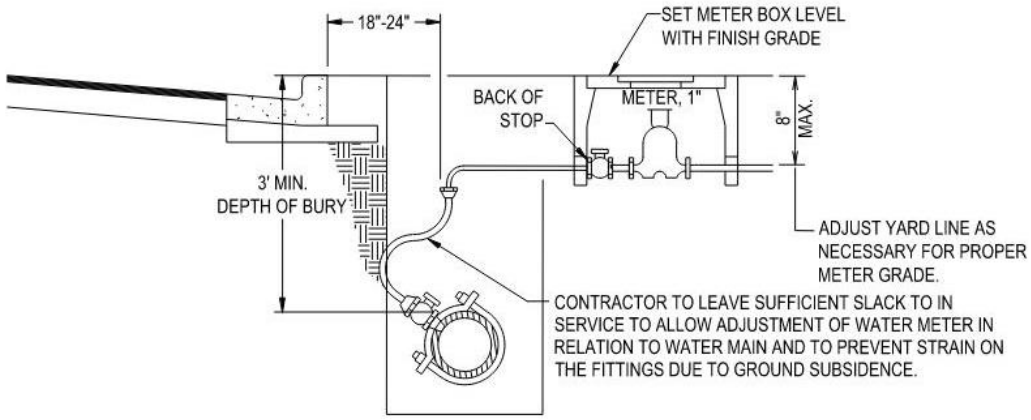
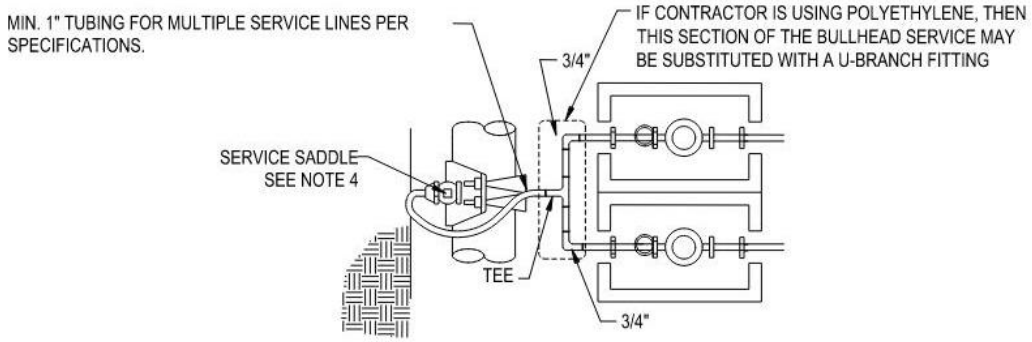
CONSTRUCTION STANDARD DETAILS		

330.2 B



SECTION



PLAN

NOTES:

1. METERS 3" AND LARGER WILL BE INSTALLED IN A CONCRETE VAULT.
2. THE METER IS TO BE LOCATED AS CLOSE TO THE MAIN AS POSSIBLE. (MIN. 2'-0" CLEARANCE). LOCATIONS SHOULD BE REVIEWED BY THE CITY INSPECTOR. VARIATIONS MAY BE APPROVED ON A CASE BY CASE BASIS ONLY.
3. FITTINGS SHALL BE BRASS AND COMPRESSION TYPE.
4. SERVICE SADDLE FOR C.I.P., D.I.P, OR A.C. PIPE SHALL BE SMITH BLAIR 313 OR FORD F202. SERVICE SADDLE FOR P.V.C PIPE SHALL BE SMITH BLAIR 317.
5. WHERE BOX IS EXPOSED TO TRAFFIC, USE CONCRETE BOX WITH CASE IRON TRAFFIC COVER WITH CAST IRON READER LID.
6. LOCATION OF METER BOX AND METER DIFFERENT THAN THESE REQUIREMENTS REQUIRES THE APPROVAL OF THE WATER DISTRIBUTION SUPERINTENDENT. APPROVED SIGNIFICANT FIELD ADJUSTMENTS MADE AS PART OF A DEVELOPMENT ARE TO BE NOTED IN THE AS-BUILTS SUBMITTED TO THE CITY.

BULLHEAD METER (OUTSIDE OF STREET)

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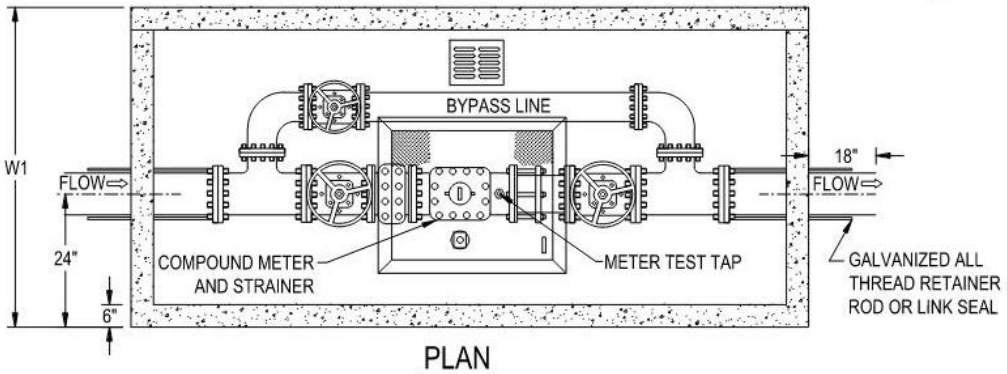
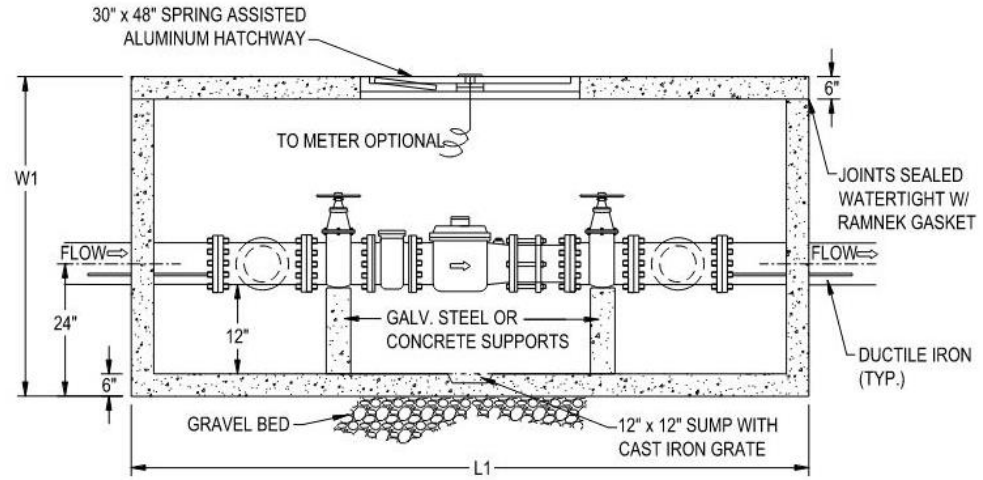
		DATE : OCTOBER 2022
CONSTRUCTION STANDARD DETAILS		

330.3



PLAN



SECTION

SPECIFICATIONS:

CONCRETE: CLASS 1 CONCRETE W/ DESIGN STRENGTH OF 4500 PSI AT 28 DAYS. UNIT IS MONOLITHIC CONSTRUCTION AT FLOOR AND FIRST STAGE OF WALL WITH SECTIONAL RISER TO REQUIRED DEPTH.

REINFORCEMENT: GRADE 60 REINFORCED. STEEL REBAR CONFORMING TO ASTM A615 ON REQUIRED CENTERS, OR EQUAL.

HATCHWAY: HINGED 1/4" ALUMINUM DIAMOND PLATE COVER WITH 1/4" EXTRUDED ALUMINUM FRAME. HATCH TO BE FURNISHED WITH STAINLESS ALUMINUM HARDWARE.

DIMENSIONS						
MODEL	SIZE	BYPASS	L1	W1	H1	WEIGHT (LBS)
DMC-3	3"	3"	8'-8"	5'-0"	4'-6"	14,000
DMC-4	4"	4"	8'-8"	5'-0"	4'-6"	14,500
DMC-6	6"	6"	11'-0"	6'-0"	4'-6"	22,000

METER BOX DETAIL FOR 3" AND LARGER METERS

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

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City of Copperas Cove

SCALE : N.T.S.

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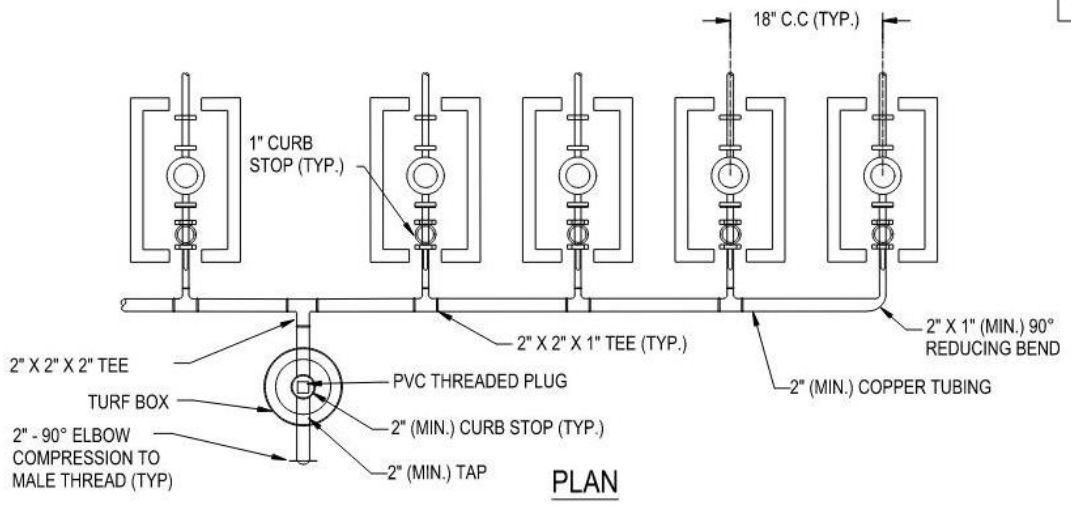
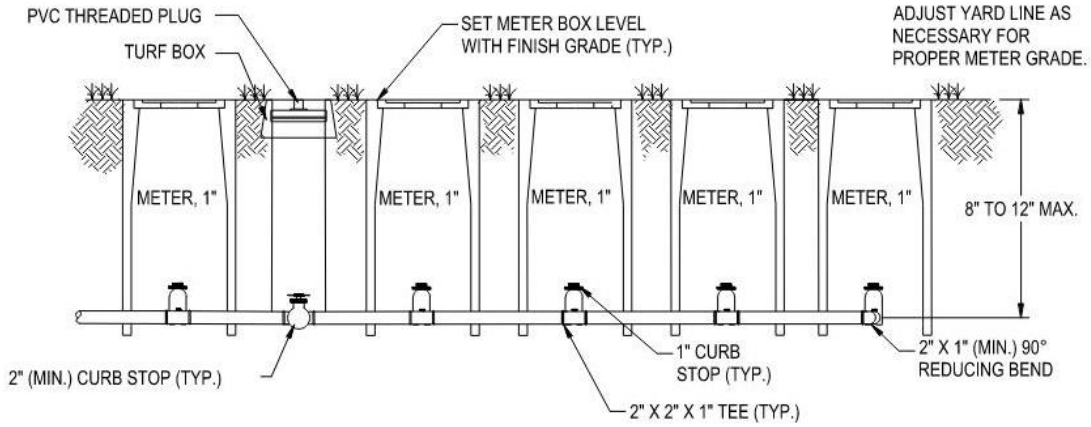
330.4



PLAN



SECTION

NOTES:
1. ALL FITTINGS SHALL BE BRASS OR COPPER COMPRESSION FITTINGS. NO PLASTIC FITTINGS SHALL BE PERMITTED.
2. CURB STOP VALVES SHALL BE MANUFACTURED BY MUELLER, FORD, OR PRE-APPROVED EQUAL. CURB STOP VALVES MUST HAVE A PLACE TO LOCK A PADLOCK WHEN ISOLATING THE LINE.

TYP. MANIFOLD

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

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City of Copperas Cove

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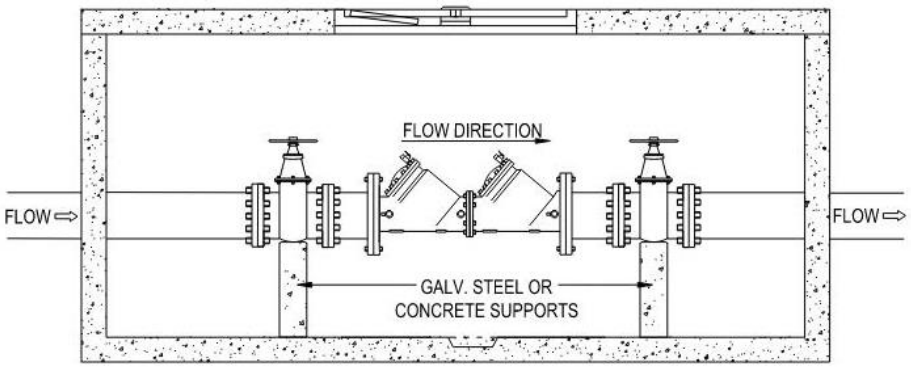
330.5



SECTION

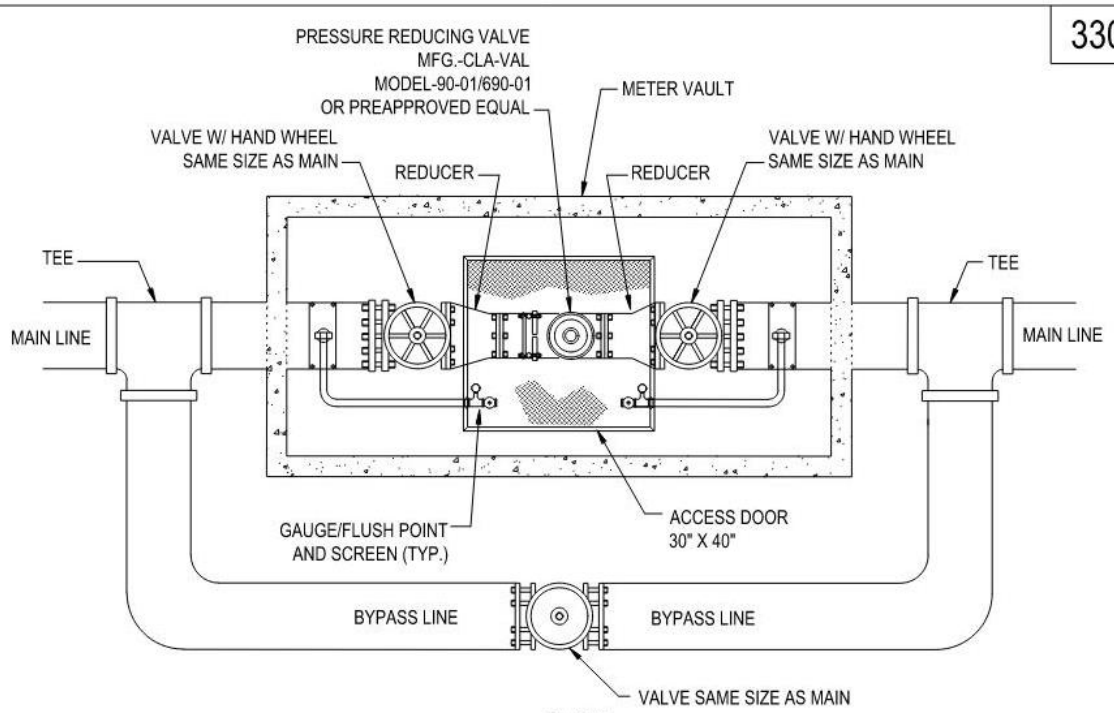
NOTES:

1. DOUBLE DETECTOR CHECK ASSEMBLY TO BE HOUSED IN AN APPROPRIATELY SIZED CONCRETE VAULT IN ACCORDANCE WITH THE SPECIFICATIONS.
2. ALL TEST PORTS SHALL HAVE PROTECTIVE CAPS.
3. UPON INSTALLATION ASSEMBLY MUST BE TESTED BY CERTIFIED TESTER AND RESULTS FURNISHED TO THE CITY OF COPPERAS COVE, WATER BILLING OFFICE. TEST RESULTS SHALL BE FURNISHED BY OWNER ON ANNUAL BASIS.
4. ALL NEW FIRE LINE SERVICES AND THOSE ENCOUNTERED IN A CONSTRUCTION PROJECT SHALL HAVE INSTALLED A LEAK DETECTOR DOUBLE CHECK VALVE WITH A DETECTION METER. THE DETECTOR IN A CONCRETE VAULT, AND WHERE POSSIBLE, CHECK VALVES SHALL BE INSTALLED IN RIGHT OF WAY.
5. VAULTS IN TRAFFIC AREAS (VEHICLE AND PEDESTRIAN) SHALL BE FLUSH. VAULTS IN NON-TRAFFIC AREAS SHALL EXTEND 6" ABOVE GRADE.
6. VAULTS IN COMMERCIAL APPLICATIONS MAY BE INSIDE THE BUILDING.

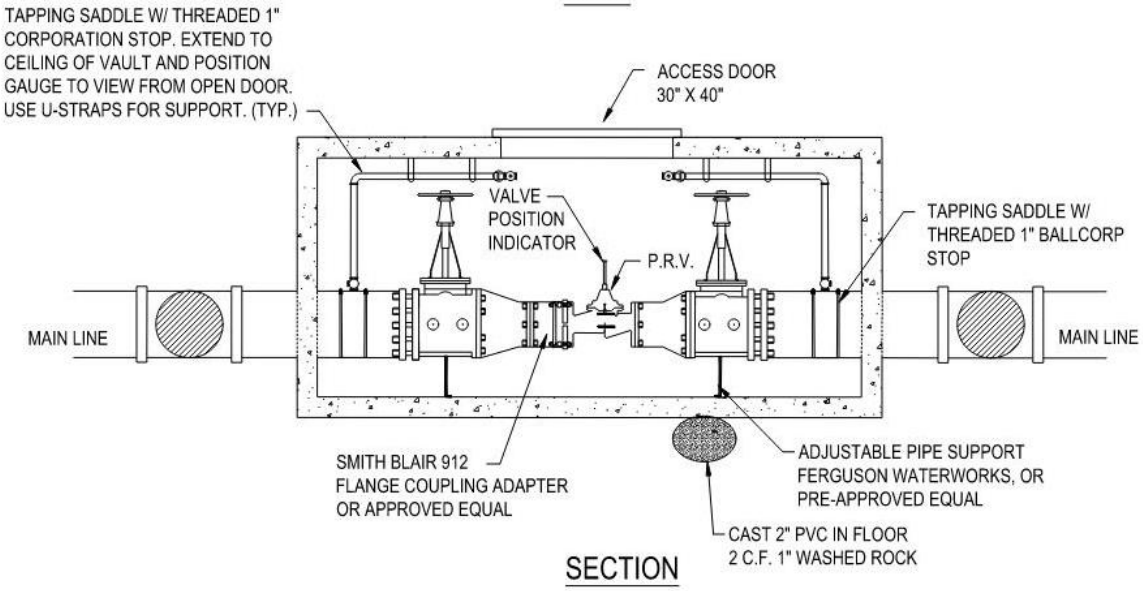
LEAK DETECTOR DOUBLE CHECK VALVE

CITY OF COPPERAS COVE DEPARTMENT OF PUBLIC WORKS	City of Copperas Cove	SCALE : N.T.S.
		DATE : APRIL 2018
CONSTRUCTION STANDARD DETAILS		

330.6



PLAN



SECTION

PRV ASSEMBLY ON NEW MAIN

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

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City of Copperas Cove

SCALE : N.T.S.

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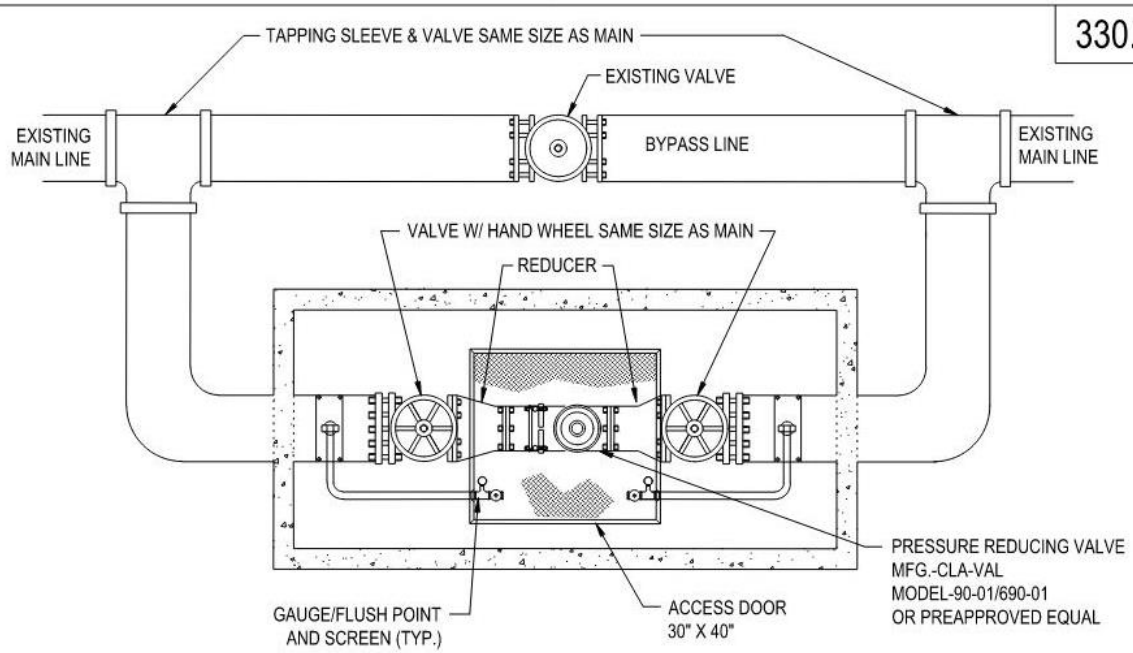
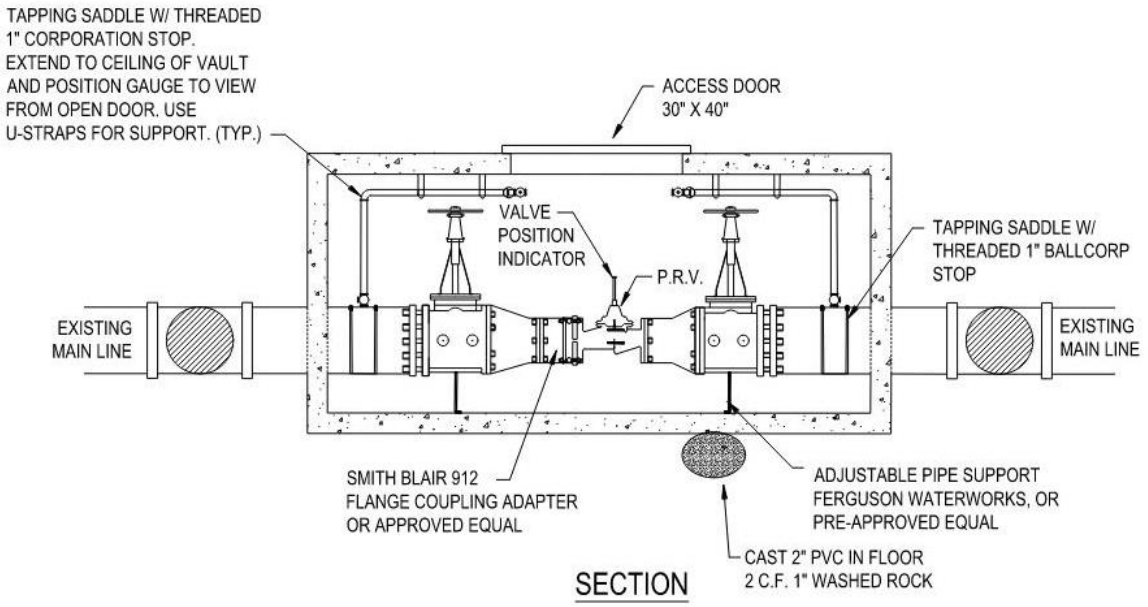
330.7



PLAN



SECTION

PRV ASSEMBLY ON EXISTING MAIN

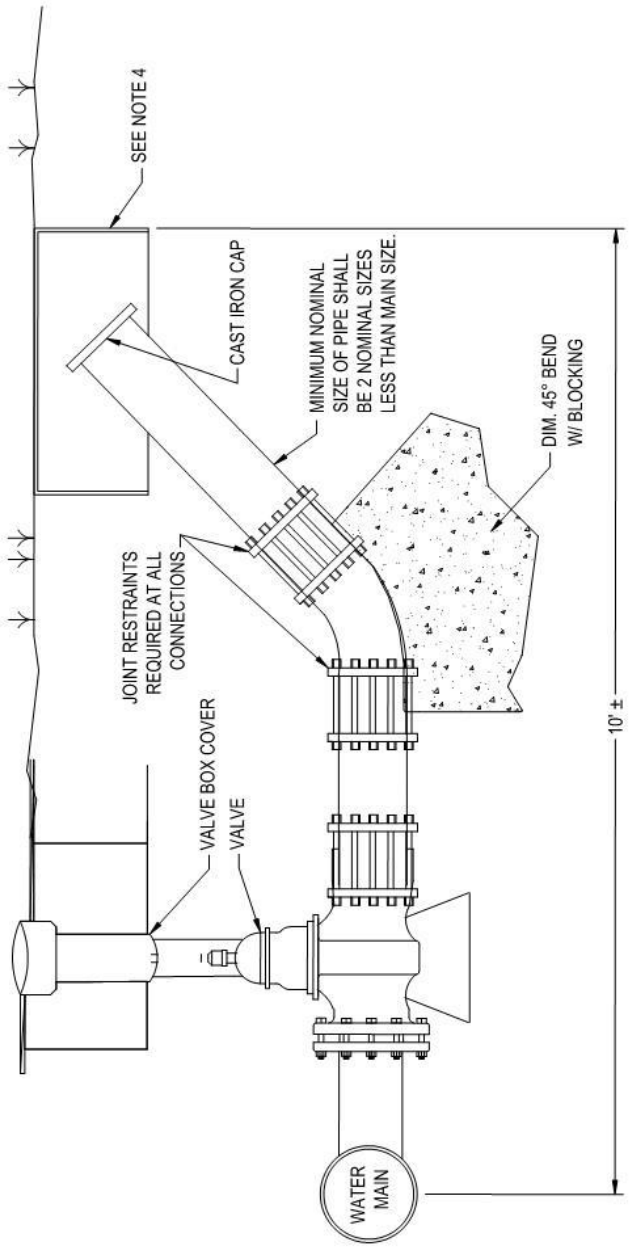
CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

CONSTRUCTION STANDARD DETAILS

City of Copperas Cove

SCALE : N.T.S.
DATE : APRIL 2018

340.1



NOTES:
1. EROSION CONTROL AND AREA DRAINAGE MEASURES AT BLOW-OFF DISCHARGE MUST BE INSTALLED TO MEET SITE CONDITIONS.
2. DISCHARGE OF CHLORINATED WATER MUST COMPLY WITH TCEQ REQUIREMENTS.
3. SIZE OF BLOW-OFF PIPING TO BE SPECIFIED BY DESIGN ENGINEER IN PROJECT PLANS.
4. SIZE AND DESIGN OF BLOW-OFF ENCLOSURE SHALL SUIT THE SITE AND SYSTEM REQUIREMENTS.

BLOW OFF ASSEMBLY

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

CONSTRUCTION STANDARD DETAILS

City of Copperas Cove

SCALE : N.T.S.
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CITY OF COPPERAS COVE
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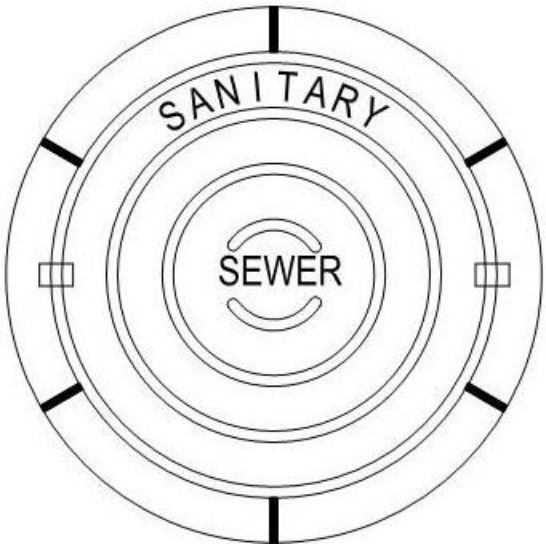
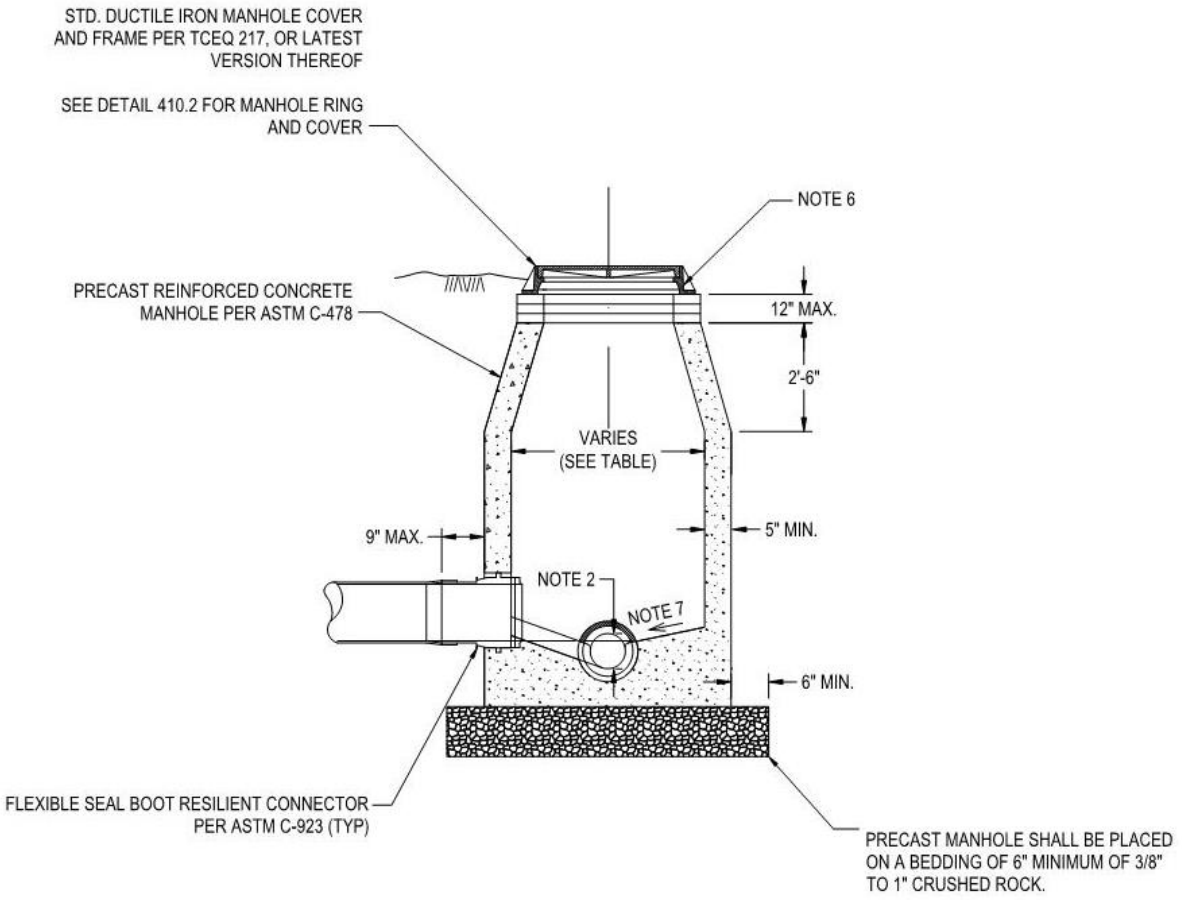
WASTEWATER DETAILS



410.1

MANHOLE DIA.	MAIN SIZE
48 IN	D < 15 IN
60 IN	18 < D < 24IN
72 IN	30 < D < 36IN
84 IN	D > 36IN



NOTE:
1. DEPTHS GREATER THAN 12' WILL REQUIRE 2 MATS OF REINFORCING STEEL IN THE BASE.
2. INVERT SHALL BE IN ACCORDANCE WITH DETAIL 410.7.
3. IN FLOODPLAINS OR AREAS OF CONCENTRATED FLOW, A BOLT DOWN WATER-TIGHT RING AND COVER SHALL BE USED, VENTED WHERE REQUIRED.
4. WARNING SIGN ONLY TO BE PLACED FOR MANHOLE IN UNDEVELOPED AREA, PER DETAIL 410.4.
5. CAST IN PLACE MANHOLES WILL REQUIRE A SEALED DESIGN SUBMITTED BY CONTRACTOR AND APPROVED BY CITY ENGINEER.
6. USE WRAPID SEAL OR PRE-APPROVED EQUAL BETWEEN RING/COVER, ADJUSTMENT RINGS, AND CONE SECTION.
7. SLOPE PER TCEQ REQUIREMENTS.

PRECAST MANHOLE

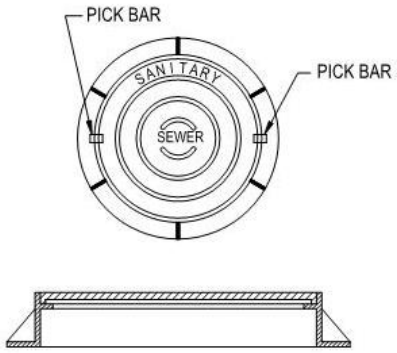
CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

CONSTRUCTION STANDARD DETAILS

City of Copperas Cove

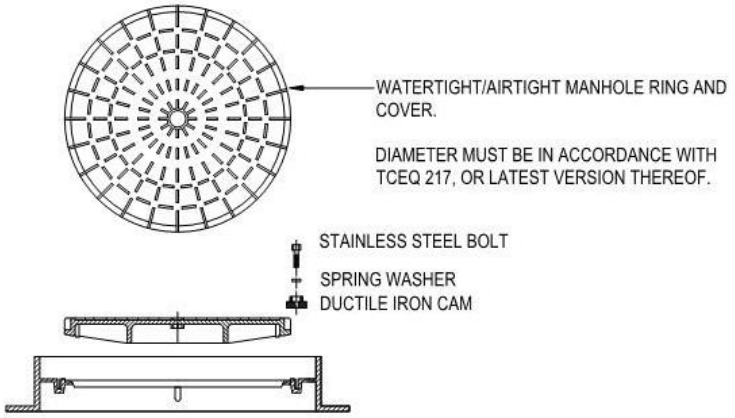
SCALE : N.T.S.
DATE : APRIL 2018

410.2



MANHOLE RING AND COVER

NOTES:
1. STANDARD MANHOLE RING AND COVER SHALL BE NEENAH R-1557, EAST JORDAN IRON WORKS OR APPROVED EQUAL.
2. DIAMETER MUST BE IN ACCORDANCE WITH TCEQ 217, OR LATEST VERSION THEREOF.



WATERTIGHT/AIRTIGHT MANHOLE RING AND COVER

MANHOLE RING AND COVER

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

CONSTRUCTION STANDARD DETAILS

City of Copperas Cove

SCALE : N.T.S.
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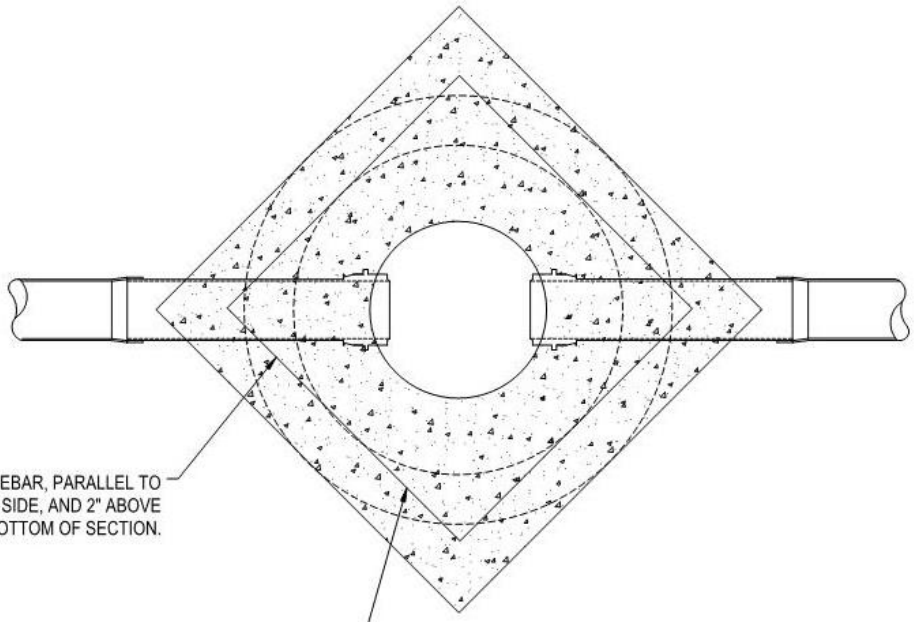
410.3



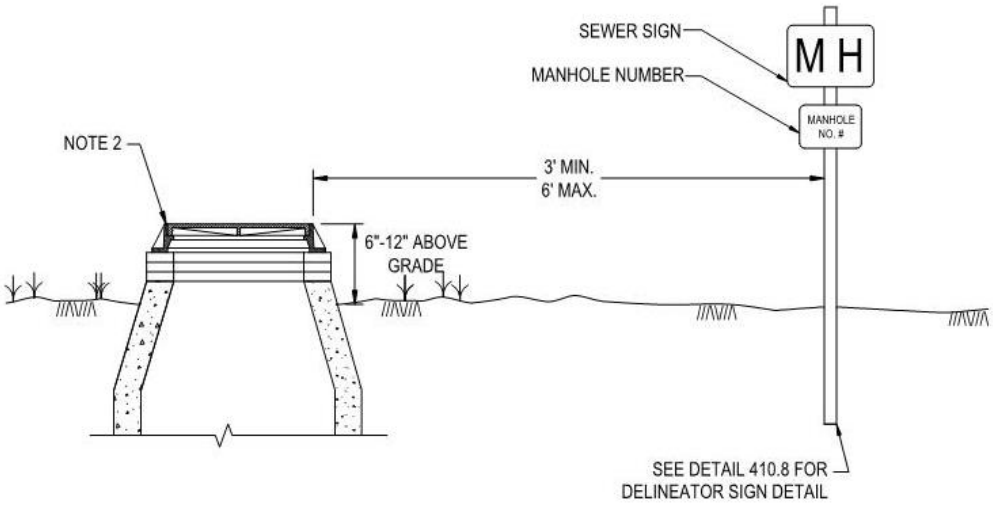
NOTES:

1. MANHOLE DIAMETER MUST BE IN ACCORDANCE WITH TCEQ 217, OR LATEST VERSION THEREOF WITH RUBBER GASKET JOINTS CONFORMING TO THE ASTM C478 AND C443, UNLESS OTHERWISE APPROVED.
2. ALL MANHOLES SHALL BE CONCRETE WITH CAST IRON FRAME AND COVER (CONFORMING TO ASTM SPECIFICATION A48, CLASS 30).
3. ALL MANHOLES SHALL HAVE A CONCENTRIC CONE. WHERE CONFLICT WITH OTHER UTILITIES OCCURS, ECCENTRIC CONE IS ALLOWED.
4. MANHOLES MAY HAVE A FLAT LID, IF APPROVED BY THE CITY, WITH A MINIMUM 30" OPENING, CONFORMING TO ASTM C478, 5000 PSI CONCRETE, TRAFFIC BEARING, AND RUBBER GASKET JOINT CONFORMING TO ASTM C443.
5. INVERTS AND FLEXIBLE SEAL BOOTS, PER ASTM C923, SHALL BE CAST INTO BASE SECTION.
6. MINIMUM DROP BETWEEN INVERTS SHALL BE ONE-TENTH OF A FOOT (0.1').
7. GRADE RINGS WITH AN I.D. TO MATCH FRAMES MINIMUM CLEAR OPENING WITH A MAXIMUM GRADE RING HEIGHT OF 1'-0", 4" MINIMUM PAVED AREAS.

STANDARD MANHOLE INSIDE ROADWAY

CITY OF COPPERAS COVE DEPARTMENT OF PUBLIC WORKS	City of Copperas Cove	SCALE : N.T.S. DATE : APRIL 2018
CONSTRUCTION STANDARD DETAILS		

410.4



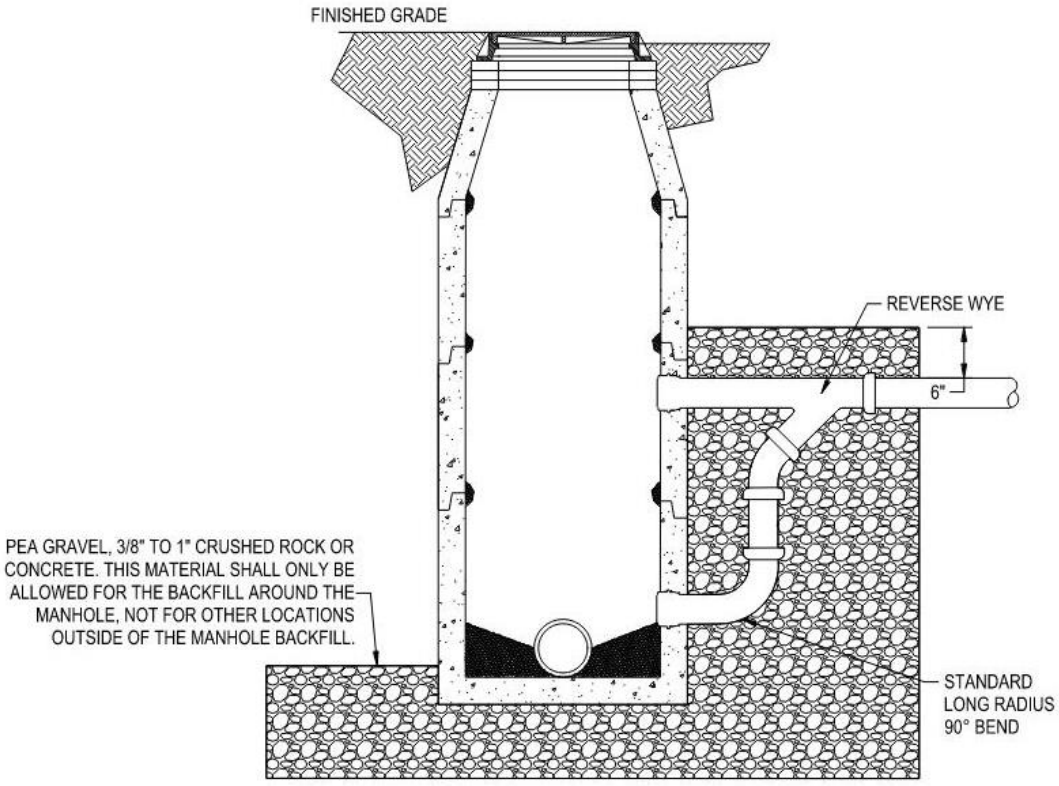
NOTES:

1. A MANHOLE SIGN MOUNTED ON A SIGN POLE IS REQUIRED FOR MANHOLES IN UNDEVELOPED AREAS. THE CONTRACTOR WILL COORDINATE WITH THE CONSTRUCTION INSPECTOR TO HAVE UTILITIES INSTALL THESE SIGNS.
2. IN FLOODPLAINS OR AREAS OF CONCENTRATED FLOW, A BOLT DOWN WATER-TIGHT RING AND COVER SHALL BE USED, VENTED WHERE REQUIRED IN ACCORDANCE WITH TCEQ 217, OR LATEST VERSION THEREOF.

MANHOLE IN UNDEVELOPED AREA

CITY OF COPPERAS COVE DEPARTMENT OF PUBLIC WORKS	City of Copperas Cove	SCALE : N.T.S.
		DATE : APRIL 2018
CONSTRUCTION STANDARD DETAILS		

410.5



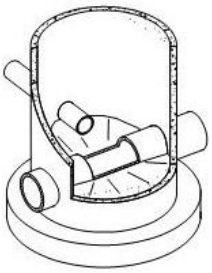
NOTES:

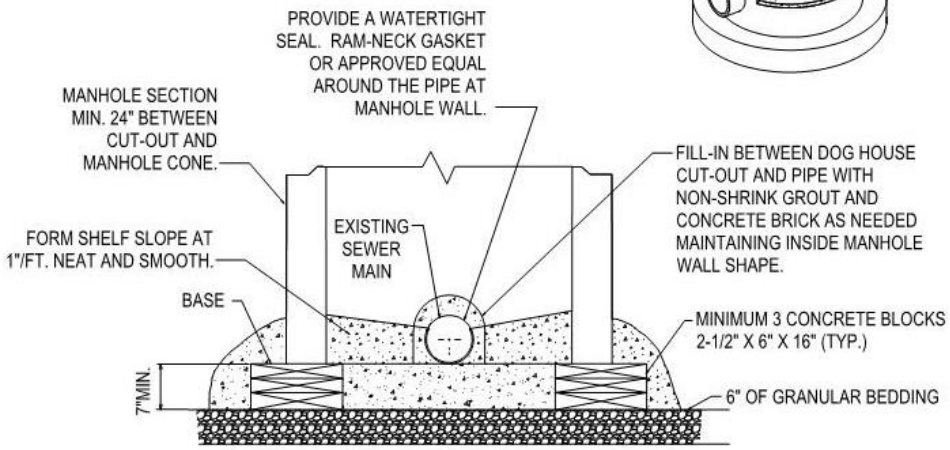
1. DROP CONNECTIONS SHALL BE REQUIRED AT LOCATIONS REQUIRED UNDER TCEQ 217, OR LATEST REVISION THEREOF.
2. A FLOW CHANNEL SHALL BE CONSTRUCTED INSIDE A MANHOLE TO DIRECT INFLUENT INTO A FLOW STREAM.
3. WHEN P.V.C. IS USED IN SANITARY SEWER LINES, SOLVENT TYPE JOINT P.V.C. FITTINGS MAY BE UTILIZED IN THE DROP ASSEMBLY ONLY.
4. INTERNAL DROP CONNECTIONS ARE NOT PERMITTED.

DROP MANHOLE PIPING

CITY OF COPPERAS COVE DEPARTMENT OF PUBLIC WORKS	City of Copperas Cove	SCALE : N.T.S.
		DATE : OCTOBER 2022
CONSTRUCTION STANDARD DETAILS		

410.6





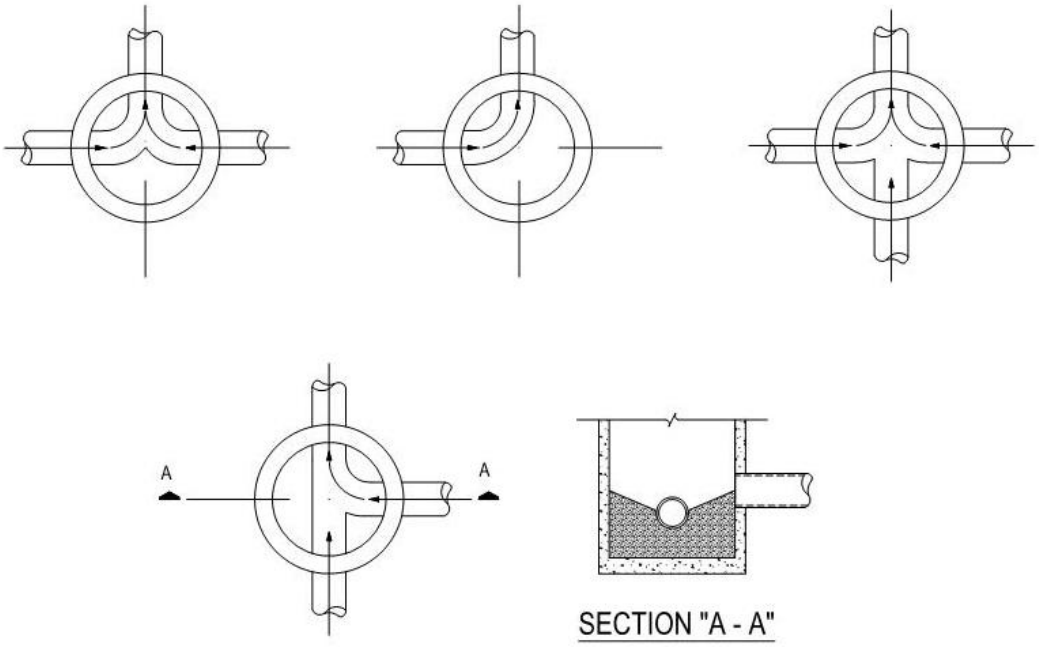
NOTE:

1. FLOW SHALL BE MAINTAINED DURING CONSTRUCTION.
2. THIS DETAIL TO BE USED WHEN A 6" OR LARGER LATERAL NECESSITATES CONSTRUCTION OF A NEW MANHOLE.
3. FOR ADDITIONAL STANDARDS NOT SHOWN, SEE PRECAST MANHOLE DETAIL 410.1 OR CAST IN PLACE MANHOLE DESIGN TO BE PROVIDED BY DESIGN ENGINEER AND APPROVED BY CITY ENGINEER AND PUBLIC WORKS DIRECTOR.
4. CONTRACTOR SHALL BE RESPONSIBLE FOR SUPPORT OF EXISTING SEWER DURING INSTALLATION OF MANHOLE.
5. DOGHOUSE OPENING MAY ONLY BE USED WHEN PLACING A NEW MANHOLE OVER AN EXISTING LINE; OTHERWISE, THE OPENING MUST BE CAST. SIZE, LOCATION, AND ANGLE OF ENTRY SHALL BE AS REQUIRED BY PLANS.
6. EXCAVATE TRENCH TO MIN. 13" BELOW BOTTOM OF EXISTING PIPE, COMPACT SUBGRADE. PLACE AND COMPACT 6" OF GRANULAR BEDDING. MONOLITHIC POUR OF MIN. 7" DEPTH, 6 SACK TOPPING MIX TO BE PLACED INSIDE, UNDER, AND OUTSIDE MANHOLE BARREL FROM SURFACE OF BEDDING, AROUND CONCRETE BLOCK RISERS, TO A POINT APPROXIMATELY AT THE SPRING LINE OF THE EXIST. PIPE.
7. DURING THE SAME POUR, THE FINISH MANHOLE SHELF SHALL BE FORMED AND FINISHED AROUND THE BARREL AND THE EXISTING PIPE AS SHOWN.
8. AFTER CONCRETE SHELF HAS CURED, THE EXISTING PIPE SHALL BE SAW-CUT ON BOTH SIDES TO THE FINISHED SHELF GRADE AND REMOVED. THE EXISTING PIPE SHALL FORM THE TROUGH OF THE MANHOLE AS SHOWN. FILE CUT THE PIPE TO GIVE SMOOTH EDGES.

DOGHOUSE MANHOLE

CITY OF COPPERAS COVE DEPARTMENT OF PUBLIC WORKS	City of Copperas Cove	SCALE : N.T.S.
		DATE : APRIL 2018
CONSTRUCTION STANDARD DETAILS		

410.7



SECTION "A - A"

NOTES:
1. INVERT CHANNELS TO BE CONSTRUCTED FOR SMOOTH FLOW WITH NO OBSTRUCTIONS.
2. HYDRAULIC SLIDES SHALL BE CONSTRUCTED BETWEEN PIPES WITH DIFFERENT INVERT ELEVATIONS PROVIDING FOR SMOOTH FLOW.
3. IF FUTURE DEVELOPEMENT/STUBOUTS ARE ANTICIPATED, THE INVERT OF THE MANHOLE SHALL BE CAST ACCORDINGLY.
4. SLOPE MANHOLE BENCH ACCORDING TO TCEQ REQUIREMENTS FROM MANHOLE WALL TO CHANNEL.
5. INVERT DEPTHS SHALL BE AS FOLLOWS:

PIPE DIAMETER	INVERT DEPTH (BENCH)
D ≤ 15"	1/2 LARGEST PIPE DIA.
15" < D ≤ 24"	3/4 LARGEST PIPE DIA.
D > 24"	EQUAL TO LARGEST PIPE DIA.

FLOW PATTERNS FOR INVERT CHANNELS

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

CONSTRUCTION STANDARD DETAILS

City of Copperas Cove

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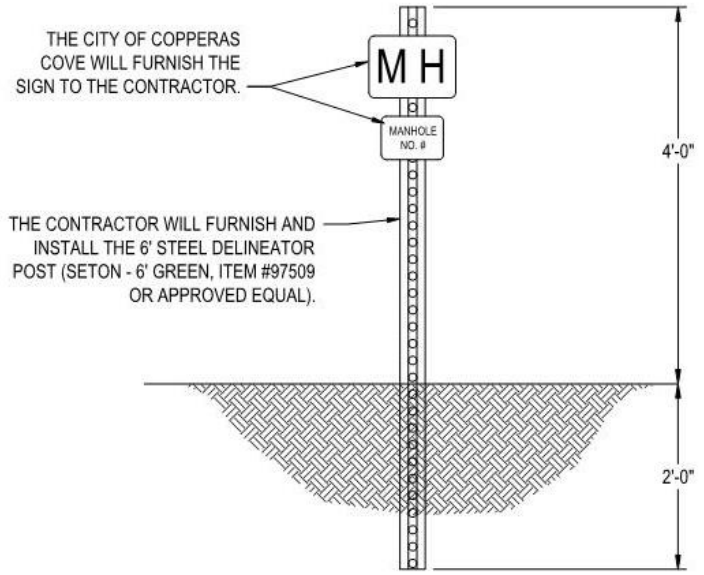
410.8



MANHOLE DELINEATOR POST DETAIL

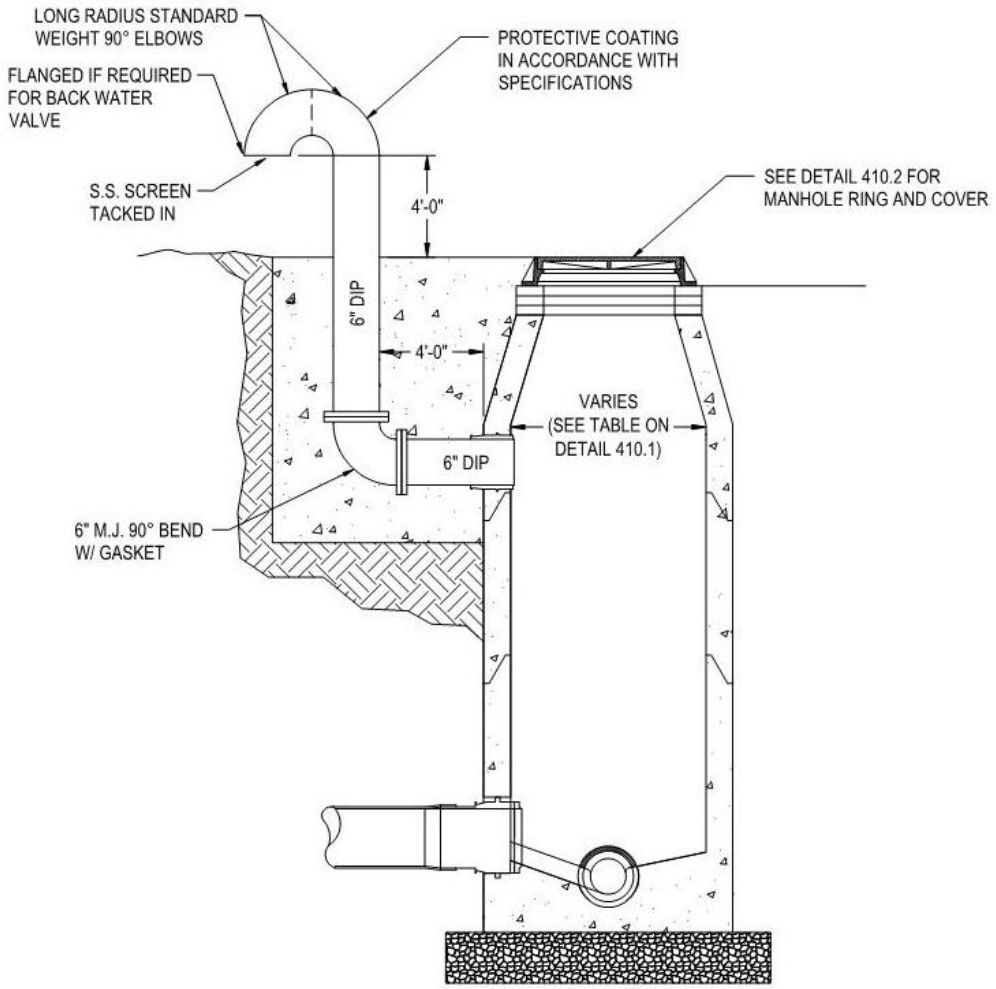
CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

CONSTRUCTION STANDARD DETAILS

City of Copperas Cove

SCALE : N.T.S.
DATE : APRIL 2018

410.9



NOTE:
1. SEE PRECAST MANHOLE DETAIL 410.1.
2. VENT OPENING TO BE MIN. 4' ABOVE FINISHED GRADE OR MIN. 1' ABOVE 100 YEAR FLOOD PLAIN ELEVATION. WHICHEVER IS HIGHER.

MANHOLE VENT

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

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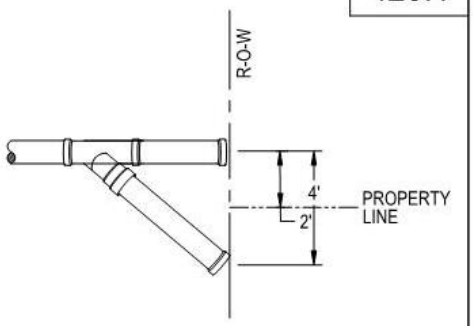
City of Copperas Cove

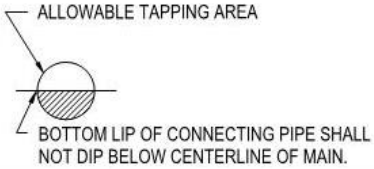
SCALE : N.T.S.
DATE : APRIL 2018

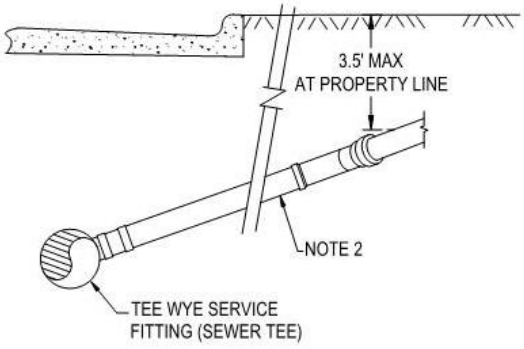
420.1

NOTES:
1. MARK EACH SERVICE END WITH A METAL T-POST PAINTED GREEN OR A 36" WOODEN LATH.
2. ALL MATERIAL SHALL BE ASTM D3034 SDR26 W/ GASKETS. SLOPE SHALL BE PER TCEQ 217.
3. ALL SERVICE CONNECTIONS & EXTENSIONS ARE TO BE INSTALLED WITH THE MAIN LINE CONSTRUCTION.
4. WHEN SERVICE CONNECTION IS DEEP, CONTRACTOR MUST PLACE A VERTICAL STACK THAT SHALL BE BROUGHT WITHIN 3-1/2 FEET BELOW NATURAL GROUND.

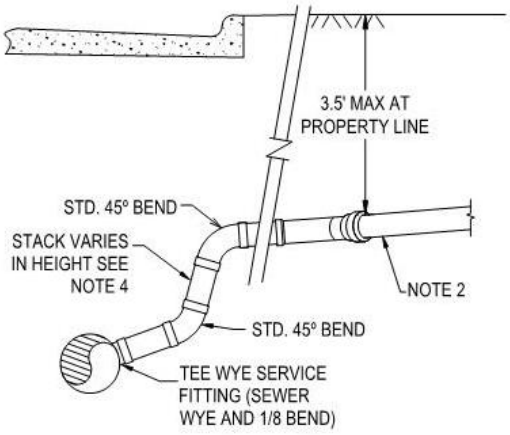


PLAN





STANDARD CONNECTION PROFILE



DEEP CONNECTION PROFILE

SANITARY SEWER SERVICE CONNECTION

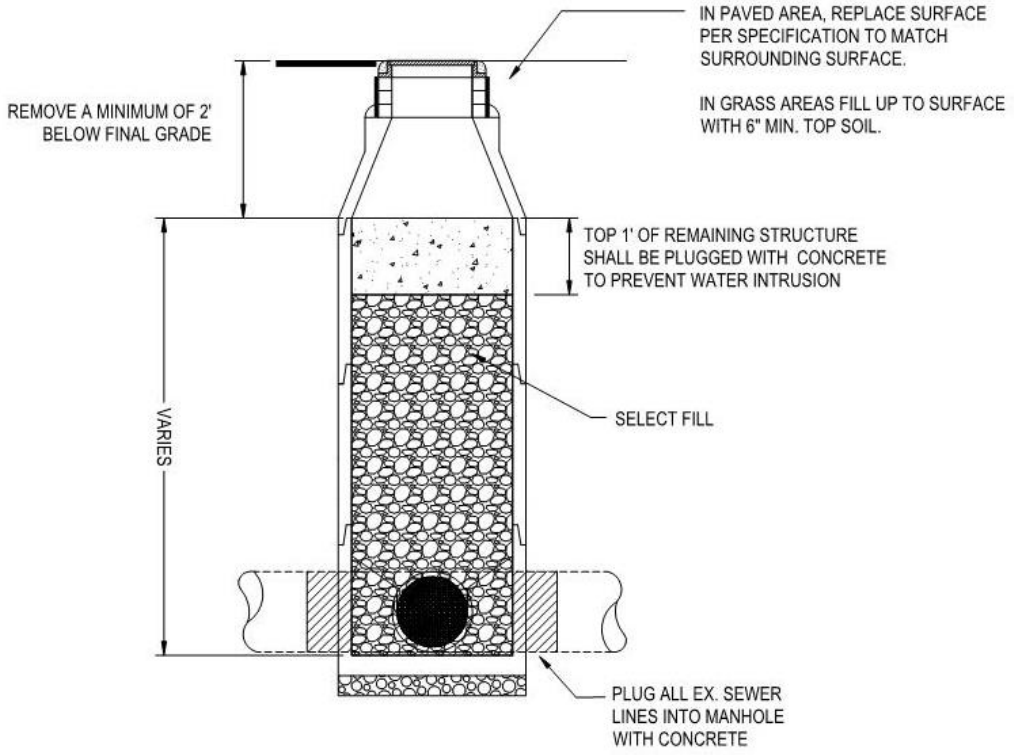
CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

CONSTRUCTION STANDARD DETAILS

City of Copperas Cove

SCALE : N.T.S.
DATE : APRIL 2018

460.1



MANHOLE ABANDONMENT

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

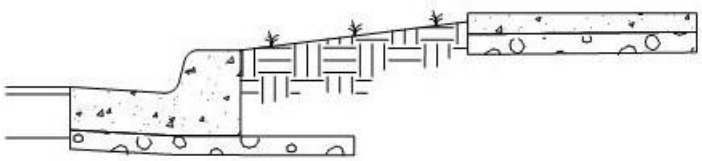
CONSTRUCTION STANDARD DETAILS

City of Copperas Cove

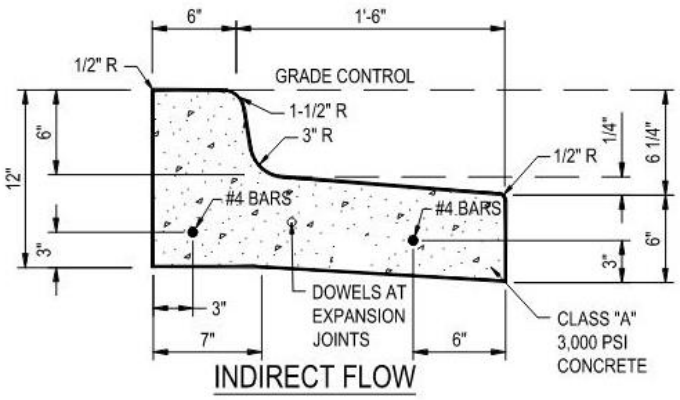
SCALE : N.T.S.
DATE : APRIL 2018

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

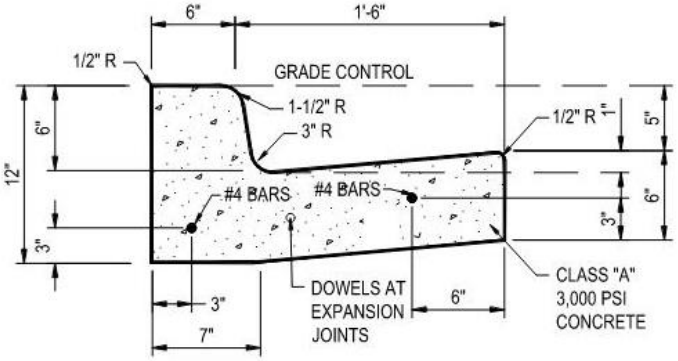
STREET DETAILS



510.1



INDIRECT FLOW



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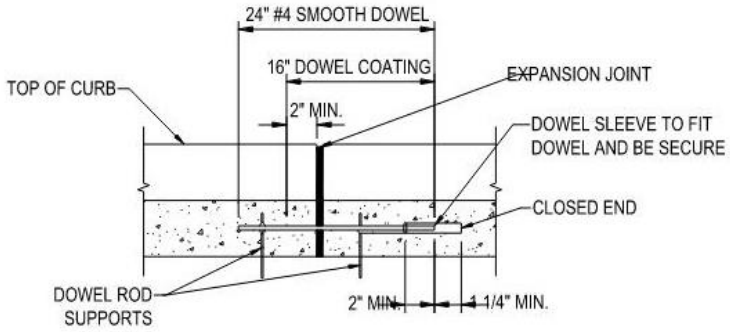


CURB DOWEL AT EXPANSION JOINT

NOTES:

1. ALL WORK AND MATERIAL SHALL CONFORM TO ASTM A615, A615M, C309 AND D1752. BROOM FINISH EXPOSED SURFACE.
2. CONTRACTION JOINT SPACING AT 24 x CONCRETE THICKNESS OR MAX.15'.
3. EXPANSION JOINT INTERVALS MAX. 80' AND AT CURB INLETS, DRIVE APPROACHES, POINTS OF CURVATURE, AND SIDEWALK EXPANSION JOINTS EXPANSION JOINT MATERIAL AS PER STD. ASTM D-1751, .
4. 1/2" EXPANSION JOINT MATERIAL SHALL BE PROVIDED WHERE CURB IS ADJACENT TO SIDEWALK, DRIVE APPROACHES, RIP-RAP, AND RADII..
5. TRANSITIONS BETWEEN CURBS OR DIFFERING CROSS SECTIONS SHALL OCCUR OVER A 20 FOOT LENGTH AS APPROVED BY THE CITY OF COPPERAS COVE.
6. ALL CONCRETE SHALL BE CLASS A, 3000 PSI.
7. ALL SURFACES THAT ARE CHIPPED OR OTHERWISE DAMAGED DURING CONSTRUCTION SHALL BE REPAIRED.
8. ONE OF THE FOLLOWING SCHEMES OF REINFORCEMENT SHALL BE REQUIRED. THE MANNER OF PLACEMENT AND LOCATION SHALL BE TO THE SATISFACTION OF THE ENGINEER OR THE CITY OF COPPERAS COVE.
   A. MANUALLY FORMED CURB AND GUTTER SHALL HAVE LONGITUDINAL REINFORCING BARS AS FOLLOWS: TWO #4 BARS SHALL BE PLACED 2" FROM BOTTOM OF GUTTER.
   B. STEEL REINFORCEMENT IS OPTIONAL FOR MACHINE LAID CURB.
10. REINFORCING BARS SHALL BE LAPPED A MINIMUM OF 15 INCH TRAVERSE SLOPE OF GUTTER SHALL CONFORM TO ADA REQUIREMENTS AT ALL PEDESTRIAN CROSSINGS.

STANDARD CURB AND GUTTER

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

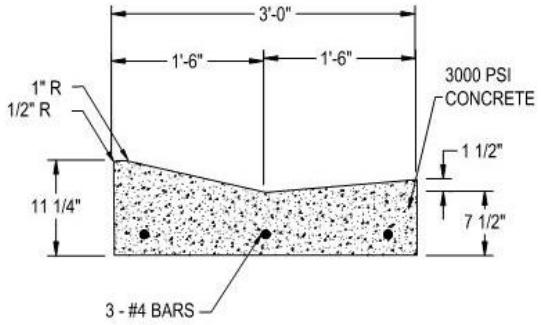
CONSTRUCTION STANDARD DETAILS

City of Copperas Cove

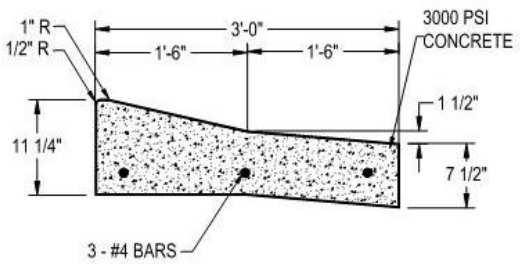
SCALE : N.T.S.

DATE : OCTOBER 2022

510.2

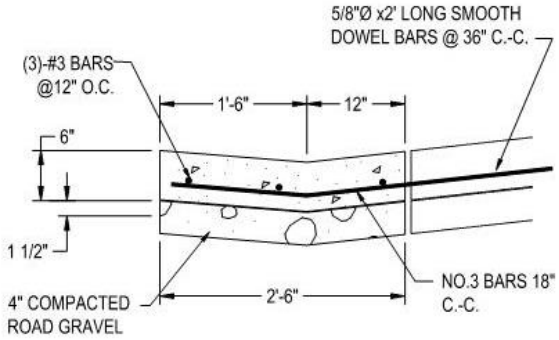


DIRECT FLOW

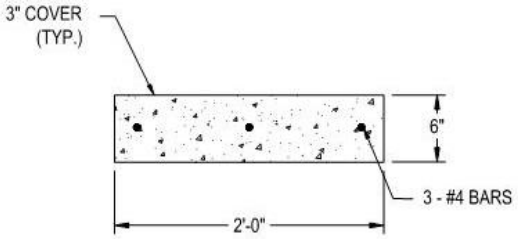


INDIRECT FLOW

MOUNTABLE CURB

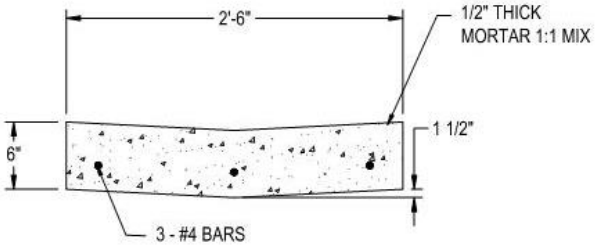


DIRECT FLOW, LAYDOWN CURB & GUTTER



NOTE:
CRACK CONTROL (DUMMY) JOINTS EVERY 10'.
CONSTRUCTION JOINT W/ EXPANSION BOARD EVERY 50'.

RIBBON CURB



VALLEY CURB

NOTE:
THE CURBS SHOWN ON THIS DETAIL MAY ONLY BE USED WITH THE PERMISSION OF THE CITY OF COPPERAS COVE ENGINEERING DEPARTMENT.

ALTERNATE CURBS: LAYDOWN, MOUNTABLE, RIBBON, & VALLEY

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

CONSTRUCTION STANDARD DETAILS

City of Copperas Cove

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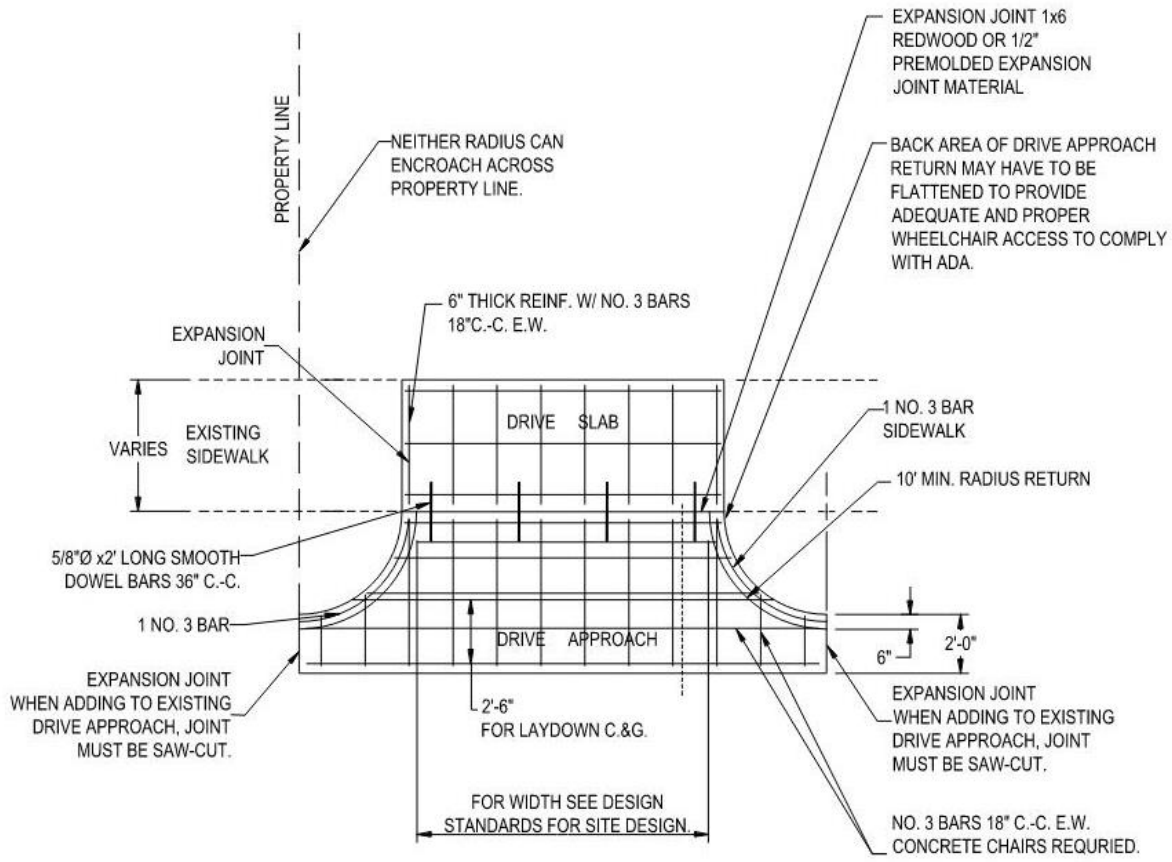
511.1

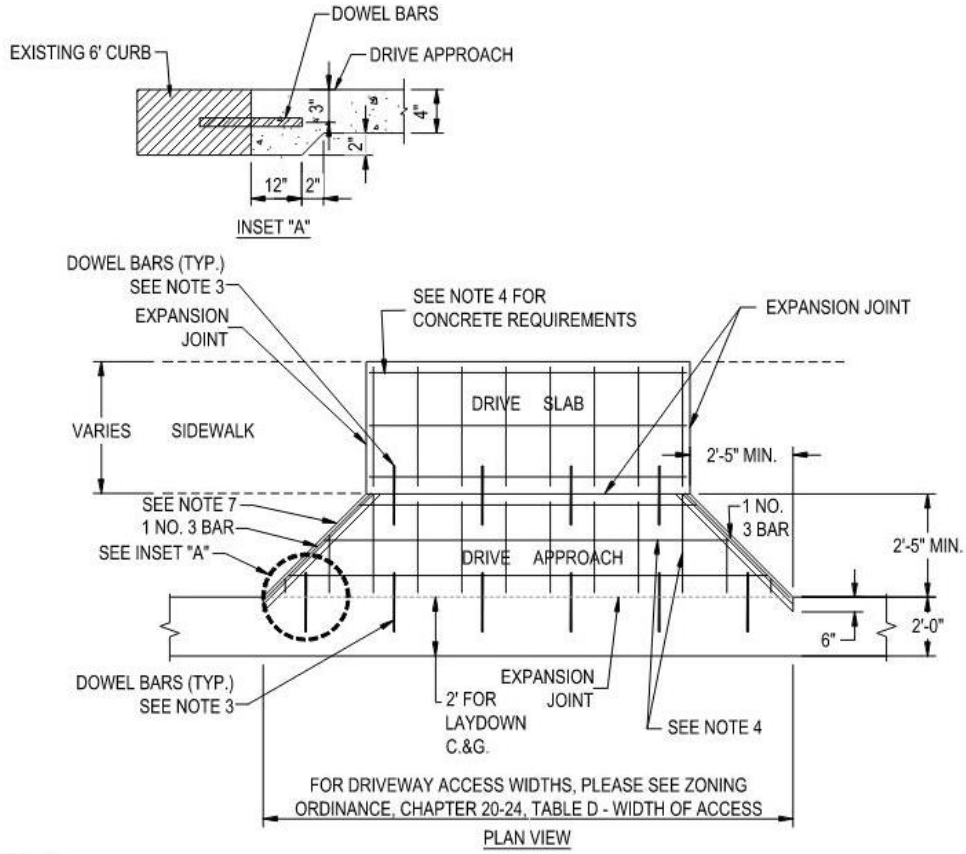


NOTE:
COMMERCIAL TYPE DRIVE APPROACHES AND TURN-OUTS (i.e. for business property) REQUIRE CITY TRAFFIC APPROVAL.

COMMERCIAL DRIVE APPROACH

CITY OF COPPERAS COVE DEPARTMENT OF PUBLIC WORKS	City of Copperas Cove	SCALE : N.T.S.
		DATE : OCTOBER 2022
CONSTRUCTION STANDARD DETAILS		

511.2



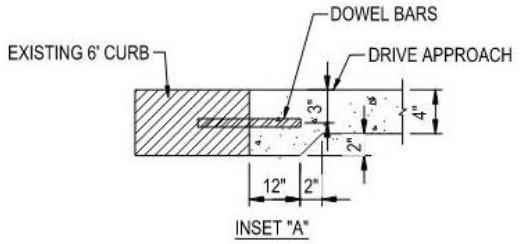
NOTES:

1. ALL SIDEWALKS SHALL MEET THE REQUIREMENTS OF THE ADA.
2. CURB MUST BE SAWED WHEN CONSTRUCTING DRIVE AT EXISTING CURB. THE EXISTING CURB AND GUTTER SHALL BE REMOVED AND REPLACED TO THE NEXT EXISTING JOINT IF THE RADIUS RETURN IS WITHIN 3 FT. OF AN EXISTING JOINT.
3. DOWEL BARS TO BE EITHER:
   #5 SMOOTH DOWELS AT TYPICAL 36-INCH SPACING (+/- 1 INCH), OR
   #3 SMOOTH DOWELS AT TYPICAL 18-INCH SPACING (+/- 1 INCH).
   DOWEL BARS MAY BE REPLACED WITH SAME-SIZED REBAR FOR DRILLED INSTALLATIONS.
4. DRIVE APPROACH TO BE MINIMUM 4-INCH THICK CLASS A CONCRETE. CONCRETE CHAIRS ARE REQUIRED FOR ALL REINFORCEMENT. REINFORCEMENT SHALL BE EITHER:
   #3 BARS AT TYPICAL 18" CENTER TO CENTER EACH WAY, OR
   6" BY 6" BY 10 GAUGE WIRE MESH
5. DRIVEWAY SLOPES SHALL COMPLY WITH THE DRAINAGE DESIGN (I.E. CONTAINING STORMWATER WITH THE STREET/ROW.)
6. WHERE SIDEWALK CONNECTS TO DRIVEWAY, DRIVEWAY SLOPES SHALL MEET ADA REQUIREMENTS.
7. IF DRIVEWAY IS NARROWER THAN THE ACCESS WIDTH (I.E. CURB CUT) THEN A FLARE IS REQUIRED BETWEEN THE ACCESS WIDTH AND DRIVEWAY. DRIVEWAY FLARE MAY BE EITHER STRAIGHT OR CURVED, AS LONG AS IT MEETS THE DIMENSION REQUIREMENTS.
8. EXPANSION JOINT MATERIAL TO BE 1X4 REDWOOD OR 1/2" PREMOLDED EXPANSION JOINT MATERIAL

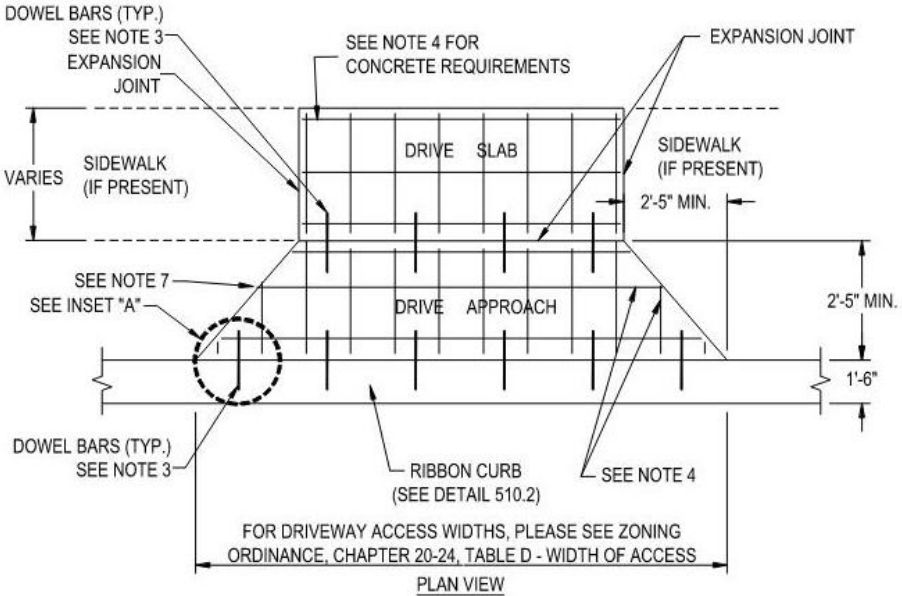
RESIDENTIAL DRIVE APPROACH

CITY OF COPPERAS COVE DEPARTMENT OF PUBLIC WORKS	City of Copperas Cove	SCALE : N.T.S.
		DATE : OCTOBER 2022
CONSTRUCTION STANDARD DETAILS		

511.3



INSET "A"



PLAN VIEW

NOTES:

1. IF PRESENT, ALL SIDEWALKS SHALL MEET THE REQUIREMENTS OF THE ADA.
2. CURB MUST BE SAWED WHEN CONSTRUCTING DRIVE AT EXISTING CURB. THE EXISTING CURB AND GUTTER SHALL BE REMOVED AND REPLACED TO THE NEXT EXISTING JOINT IF THE RADIUS RETURN IS WITHIN 3 FT. OF AN EXISTING JOINT.
3. DOWEL BARS TO BE EITHER:
   #5 SMOOTH DOWELS AT TYPICAL 36-INCH SPACING (+/- 1 INCH), OR
   #3 SMOOTH DOWELS AT TYPICAL 18-INCH SPACING (+/- 1 INCH).
   DOWEL BARS MAY BE REPLACED WITH SAME-SIZED REBAR FOR DRILLED INSTALLATIONS.
4. DRIVE APPROACH TO BE MINIMUM 4-INCH THICK CLASS A CONCRETE. CONCRETE CHAIRS ARE REQUIRED FOR ALL REINFORCEMENT. REINFORCEMENT SHALL BE EITHER:
   #3 BARS AT TYPICAL 18" CENTER TO CENTER EACH WAY, OR
   6" BY 6" BY 10 GAUGE WIRE MESH
5. DRIVEWAY SLOPES SHALL COMPLY WITH THE DRAINAGE DESIGN (I.E. CONTAINING STORMWATER WITH THE STREET/ROW.)
6. WHERE SIDEWALK CONNECTS TO DRIVEWAY, DRIVEWAY SLOPES SHALL MEET ADA REQUIREMENTS.
7. IF DRIVEWAY IS NARROWER THAN THE ACCESS WIDTH (I.E. CURB CUT) THEN A FLARE IS REQUIRED BETWEEN THE ACCESS WIDTH AND DRIVEWAY. DRIVEWAY FLARE MAY BE EITHER STRAIGHT OR CURVED, AS LONG AS IT MEETS THE DIMENSION REQUIREMENTS.
8. EXPANSION JOINT MATERIAL TO BE 1X4 REDWOOD OR 1/2" PREMOLDED EXPANSION JOINT MATERIAL

RURAL DRIVE APPROACH

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

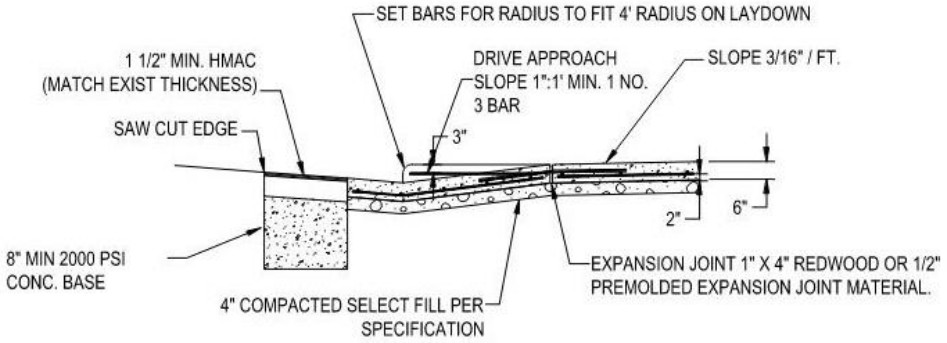
CONSTRUCTION STANDARD DETAILS

City of Copperas Cove

SCALE : N.T.S.
DATE : OCTOBER 2022

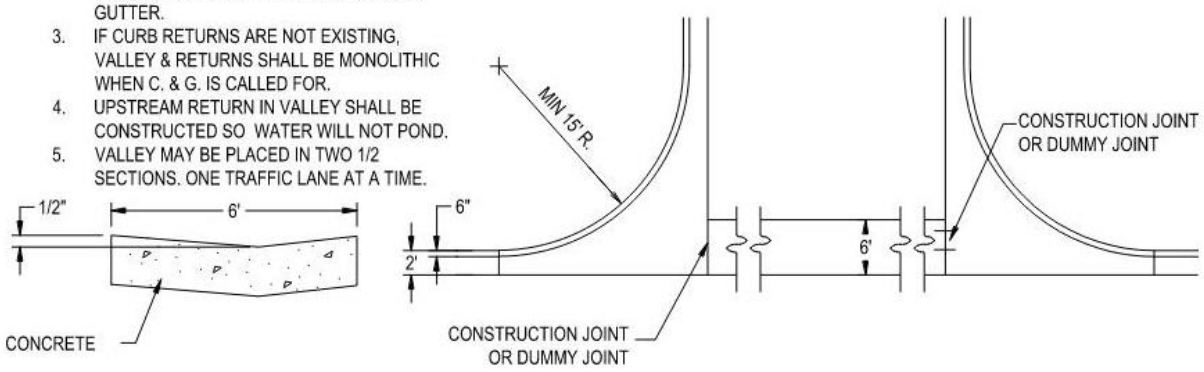
511.4

NOTE:
REQUIRED IF REMOVAL OF EXISTING CURB & GUTTER DOES NOT LEAVE A SMOOTH SURFACE AND ALIGNMENT ALONG ASPHALT & BASE.



STREET TIE-IN
NEW DRIVE APPROACH ON EXIST STREET

NOTES:
1. VALLEY GUTTERS REQUIRED PER ORDINANCES.
2. CURB & GUTTER TO BE PAID FOR SEPARATELY FROM CONCRETE VALLEY AT THE CONTRACT UNIT PRICE FOR CURB & GUTTER.
3. IF CURB RETURNS ARE NOT EXISTING, VALLEY & RETURNS SHALL BE MONOLITHIC WHEN C. & G. IS CALLED FOR.
4. UPSTREAM RETURN IN VALLEY SHALL BE CONSTRUCTED SO WATER WILL NOT POND.
5. VALLEY MAY BE PLACED IN TWO 1/2 SECTIONS. ONE TRAFFIC LANE AT A TIME.



STANDARD VALLEY

STREET TIE-IN: NEW DRIVE APPROACH ON EXISTING STREET

CITY OF COPPERAS COVE
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City of Copperas Cove

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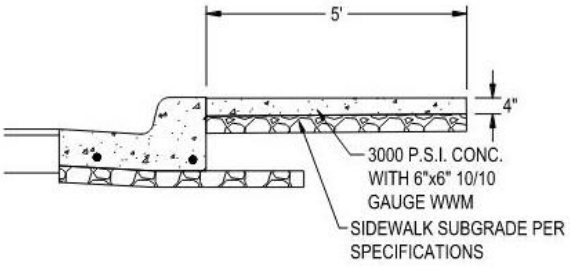
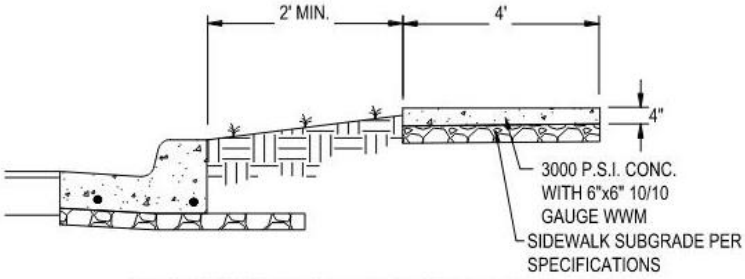
511.5



SIDEWALK DIRECTLY BEHIND CURB

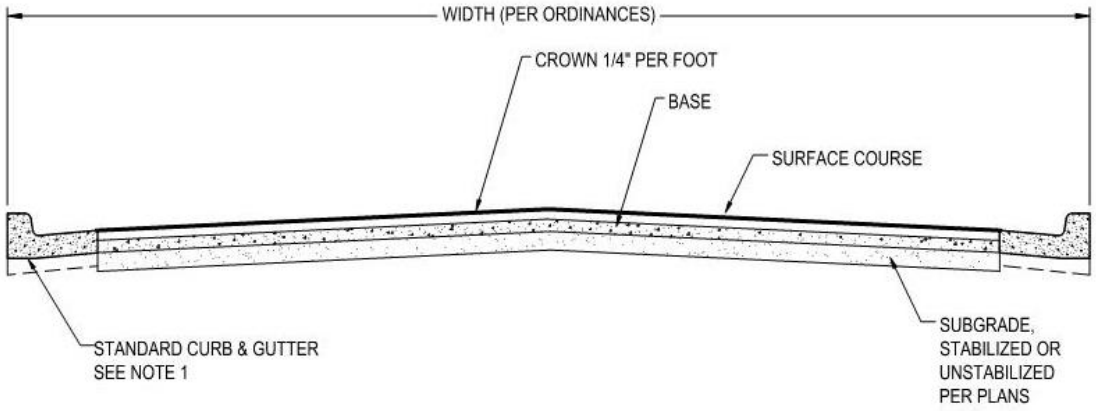


SIDEWALK NOT DIRECTLY BEHIND CURB

NOTE:
SIDEWALK SLOPE PER CITY OF COPPERAS COVE STANDARD SPECIFICATIONS.

STANDARD SIDEWALK		
CITY OF COPPERAS COVE DEPARTMENT OF PUBLIC WORKS	City of Copperas Cove	SCALE : N.T.S. DATE : APRIL 2018
CONSTRUCTION STANDARD DETAILS		

540.1



NOTES:

1. LIP OF GUTTER SHALL BE SAME ELEVATION AS TOP OF SURFACE COURSE. IF BOTTOM OF CURB DOESN'T EXTEND TO TOP OF SUBGRADE FILL MUST BE ONE OF THE FOLLOWING:
   - CONCRETE (EXTEND DEPTH OF CURB)
   - 4" MINIMUM COMPACTED ROAD GRAVEL
   - 4" MINIMUM COMPACTED STABILIZED SUBGRADE MATERIAL

2. THICKNESS OF SURFACE COURSE, BASE AND SUBGRADE SHALL BE PER STANDARD SPECIFICATIONS.

TYPICAL STREET SECTION

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

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City of Copperas Cove

SCALE : N.T.S.
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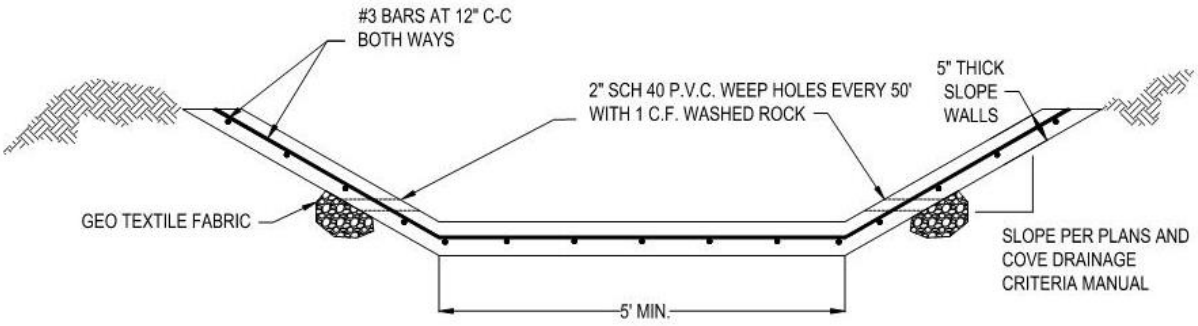
CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

DRAINAGE DETAILS

610.1



NOTES:
1. CHANNEL WALLS WILL BE DESIGNED TO SUIT PROJECT SPECIFIC SITE.
2. CONCRETE MUST BE PLACED TO ENSURE POSITIVE DRAINAGE SLOPE.
3. PLEASE REFER TO CONCRETE SPECIFICATION FOR CONCRETE REQUIREMENTS.

CONCRETE LINED CHANNEL

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

CONSTRUCTION STANDARD DETAILS

City of Copperas Cove

SCALE : N.T.S.
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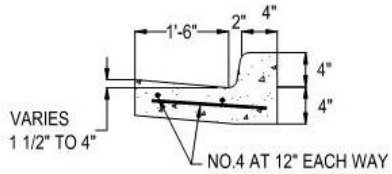
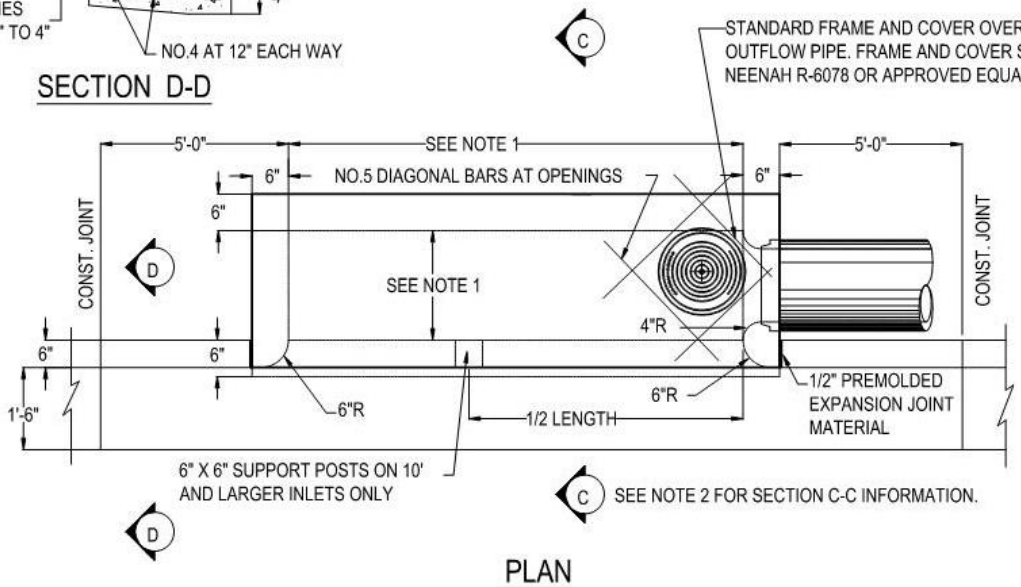
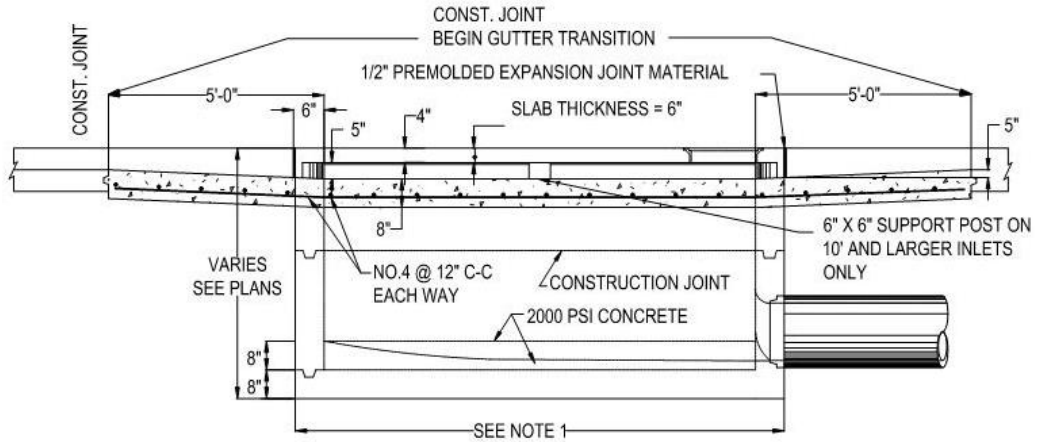
620.1



SECTION D-D



PLAN



FRONT

NOTES:
1. DIMENSIONS OF DRAINAGE INLET SHALL CONFORM TO LATEST DRAINAGE CRITERIA MANUAL REQUIREMENTS.
2. FOR SECTION C-C, SEE DETAIL 620.2.

STANDARD CAST IN PLACE INLET: PLAN AND FRONT

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

CONSTRUCTION STANDARD DETAILS

City of Copperas Cove

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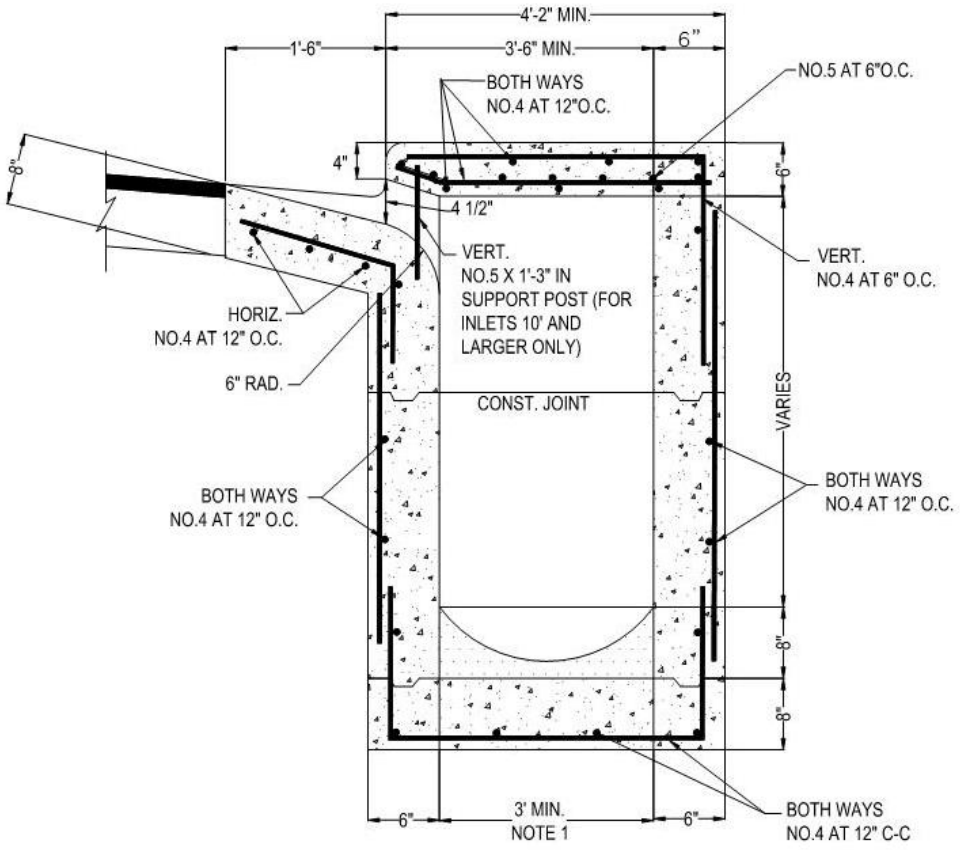
620.2



SECTION C-C

NOTES:
1. DEPTH OF DRAINAGE INLET SHALL CONFORM TO LATEST DRAINAGE CRITERIA MANUAL DESIGN REQUIREMENTS.
2. STEEL IN END WALL SAME AS STEEL IN SIDE WALL.

STANDARD CAST IN PLACE INLET: SIDE SECTION

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City of Copperas Cove

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620.3

NOTES:
1. STANDARD MANHOLE RING AND COVER SHALL BE EAST JORDAN IRON WORKS OR APPROVED EQUAL.
2. DIAMETER MUST BE IN ACCORDANCE DRAINAGE CRITERIA MANUAL.

STORM SEWER MANHOLE COVER

CITY OF COPPERAS COVE
DEPARTMENT OF PUBLIC WORKS

CONSTRUCTION STANDARD DETAILS

City of Copperas Cove

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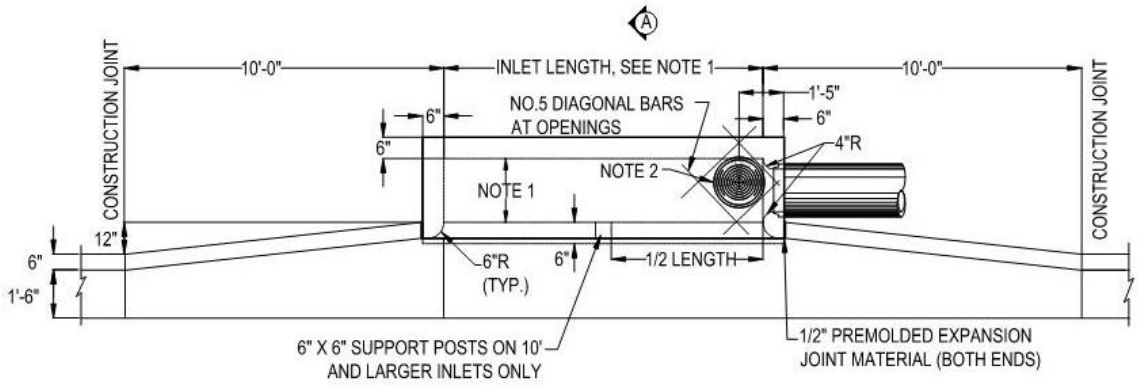
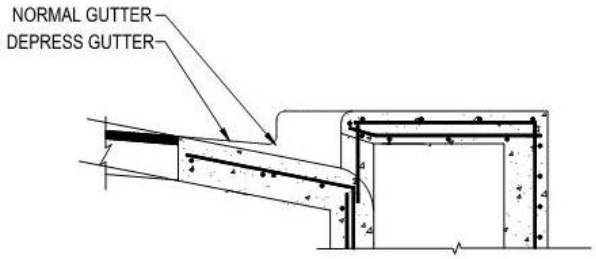
620.4



PLAN

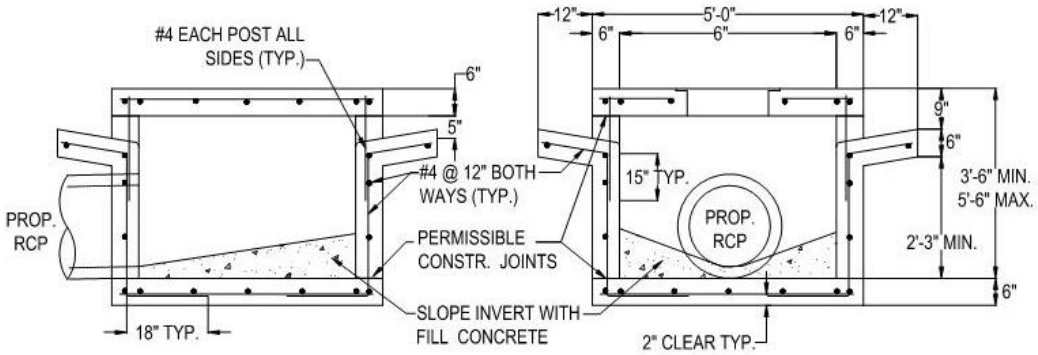


SECTION A-A
SEE NOTE 3

NOTES:
1. DIMENSIONS OF DRAINAGE INLET SHALL CONFORM TO LATEST DRAINAGE CRITERIA MANUAL REQUIREMENTS.
2. STANDARD FRAME AND COVER OVER CENTER OF OUTFLOW PIPE. FRAME AND COVER SHALL BE NEENAH R-6078 OR APPROVED EQUAL.
3. FOR REINFORCEMENT REQUIREMENTS, REFERENCE DETAIL 620.2. SECTION C-C TO SHOW NORMAL AND DEPRESS GUTTER.
4. LAP ALL CORNER BARS MINIMUM 40 X DIAMETER.

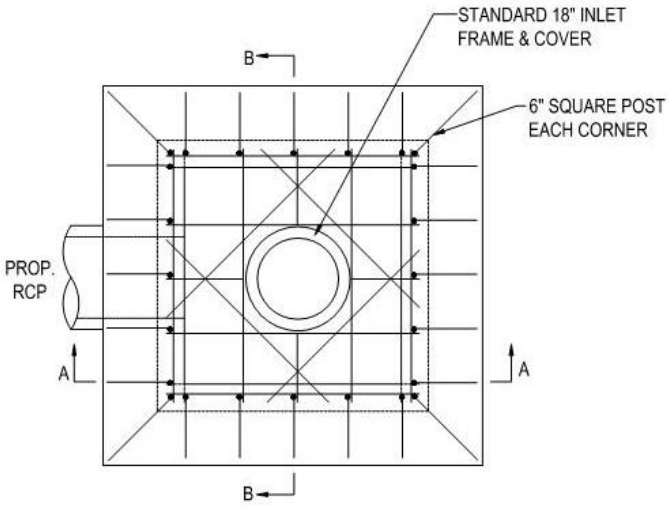
RECESSED INLET		
CITY OF COPPERAS COVE DEPARTMENT OF PUBLIC WORKS	City of Copperas Cove	SCALE : N.T.S. DATE : APRIL 2018
CONSTRUCTION STANDARD DETAILS		

620.5



ELEVATION-SECTION A-A

ELEVATION-SECTION B-B



PLAN

NOTES:
1. CHAMFER ALL EXPOSED EDGES 3/4".
2. REINFORCING STEEL SHALL BE CUT OR FIELD-BENT AS REQUIRED TO CLEAR PIPE AND INLET FRAME OPENING. ALL CUT STEEL SHALL BE REPLACED WITH ADDITIONAL DIAGONAL BARS OF THE SAME DIAMETER.
3. CONCRETE COVERAGE OF STEEL SHALL BE 2" MIN. AT ALL SURFACES.

4-SIDED AREA INLET

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City of Copperas Cove

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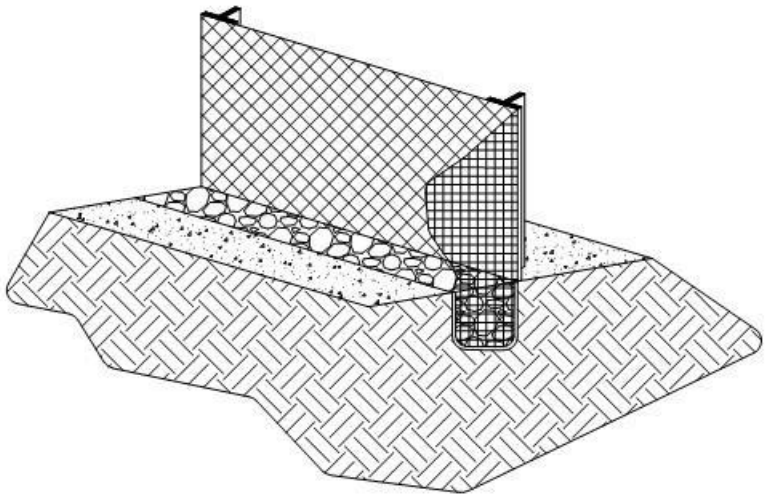
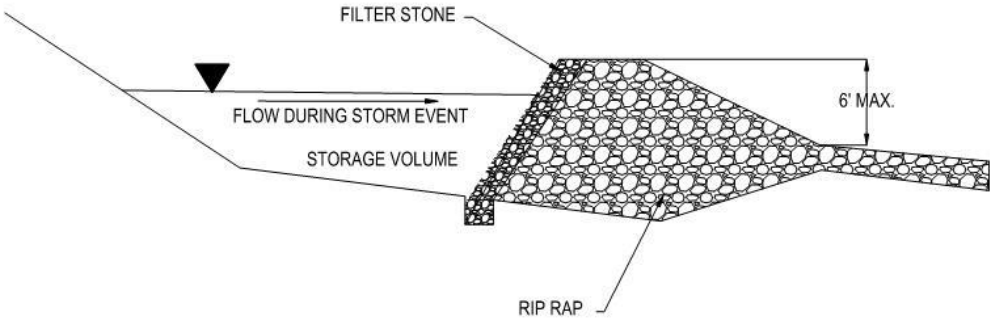
CITY OF COPPERAS COVE

DEPARTMENT OF PUBLIC WORKS

EROSION CONTROL DETAILS



720.2



NOTE:
1. STONE OUTLET SEDIMENT TRAPS ARE USED FOR SITUATIONS WHERE FLOWS ARE CONCENTRATED IN A DRAINAGE SWALE OR CHANNEL.
2. FLEXAMAT OR PRE-APPROVED EQUAL TO BE PLACED ON TOP OF RIP RAP TO ENABLE MOWING OVER TOP OF STONE OUTLET SEDIMENT TRAP.

STONE OUTLET SEDIMENT TRAP

CITY OF COPPERAS COVE
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City of Copperas Cove

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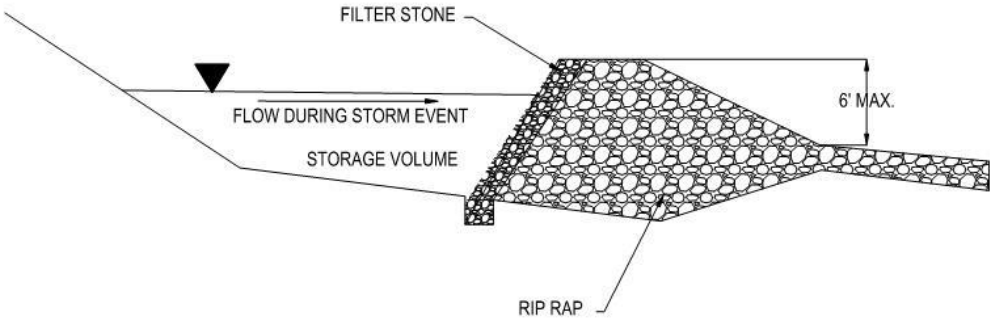
720.2



NOTE:
1. STONE OUTLET SEDIMENT TRAPS ARE USED FOR SITUATIONS WHERE FLOWS ARE CONCENTRATED IN A DRAINAGE SWALE OR CHANNEL.
2. FLEXAMAT OR PRE-APPROVED EQUAL TO BE PLACED ON TOP OF RIP RAP TO ENABLE MOWING OVER TOP OF STONE OUTLET SEDIMENT TRAP.

STONE OUTLET SEDIMENT TRAP

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City of Copperas Cove

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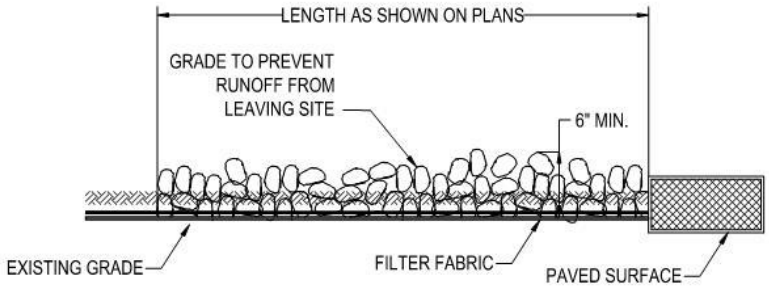
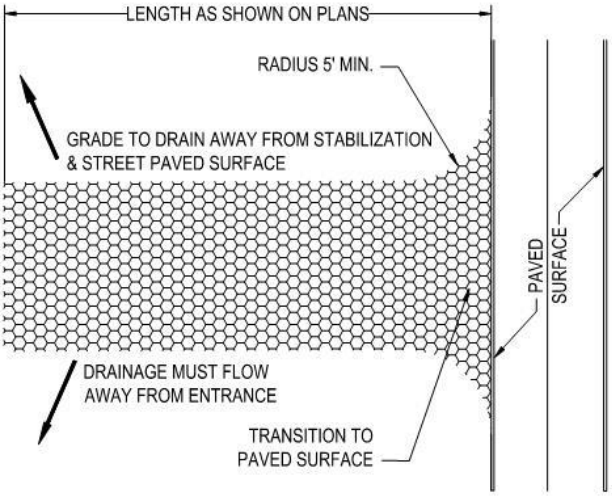
720.3



PROFILE VIEW



PLAN VIEW

NOTE:
STABILIZED CONSTRUCTION ENTRANCES SHALL BE USED FOR SITES IN WHICH SIGNIFICANT TRUCK TRAFFIC OCCURS ON A DAILY BASIS.

STABILIZED CONSTRUCTION ENTRANCE		
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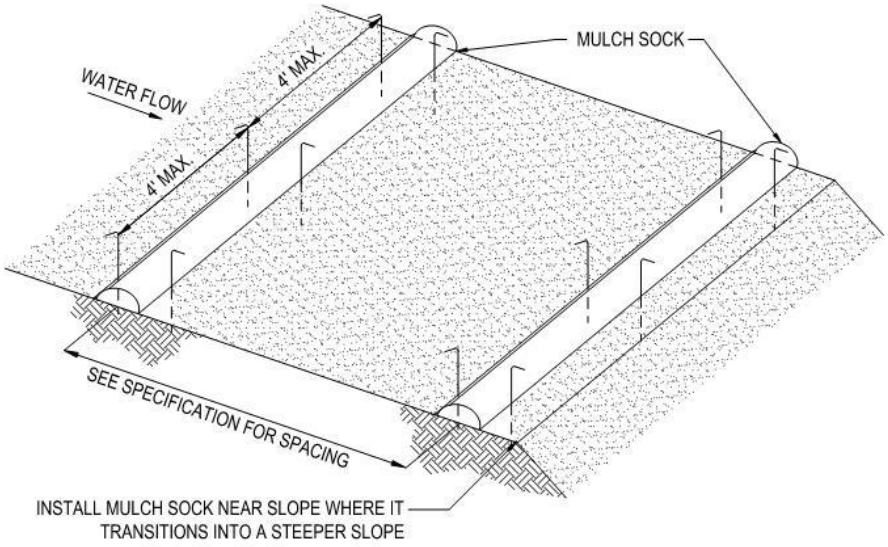
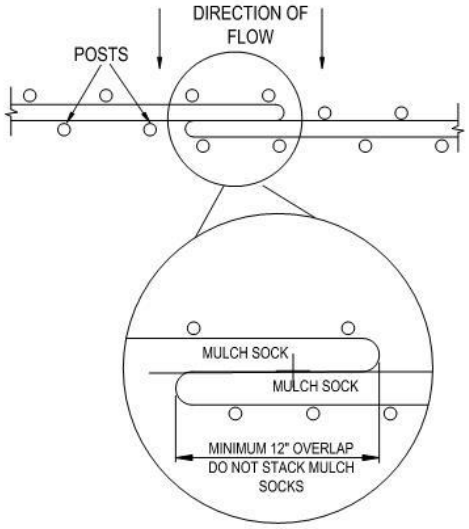
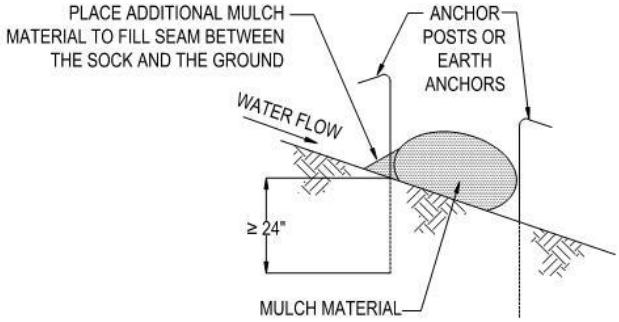
720.4





OVERLAP DETAIL



ANCHOR DETAIL

MULCH SOCK

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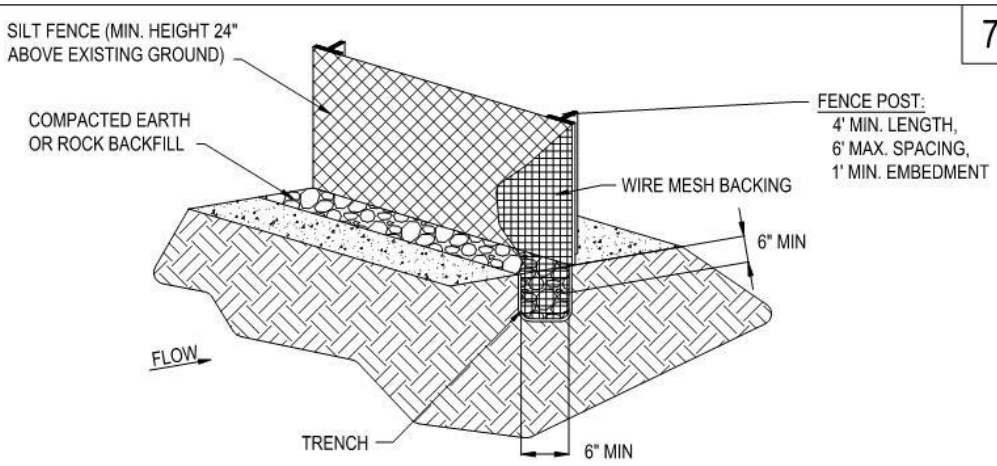
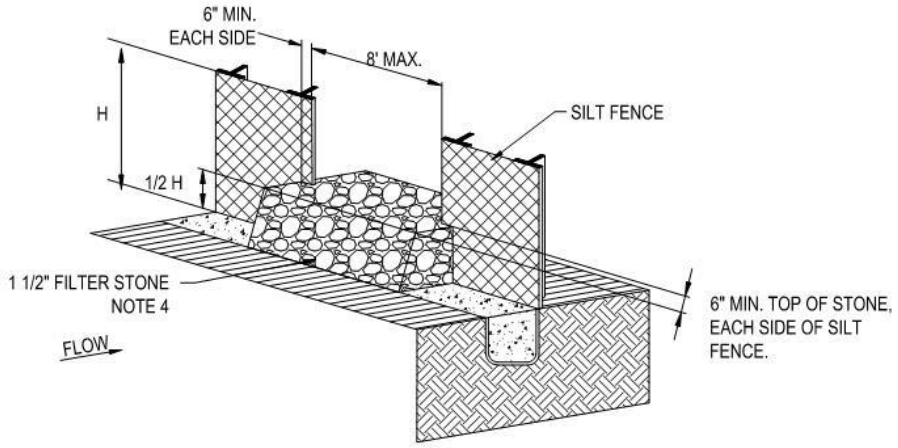
720.5



SILT FENCE



STONE OVERFLOW STRUCTURE

NOTES:

1. FILTER STONE FOR AN OVERFLOW STRUCTURE SHALL BE 1 1/2" WASHED STONE CONTAINING NO FINE MATERIAL. ANGULAR SHAPED STONE IS PREFERABLE TO ROUNDED SHAPED STONE.
2. FENCE POSTS SHALL BE GALVANIZED STEEL OR EQUIVALENT AND MAY BE T-SECTION OR L-SECTION, 1.3 POUNDS PER LINEAR FOOT MINIMUM, AND 4 FEET IN LENGTH MINIMUM. WOOD POSTS MAY BE USED DEPENDING ON ANTICIPATED LENGTH OR SERVICE AND PROVIDED THEY ARE 4 FEET IN LENGHT MINIMUM AND HAVE A NOMINAL CROSS SECTION OF 2 INCHES BY 4 INCHES FOR PINE OR 2 INCHES BY 2 INCHES FOR HARDWOODS.
3. SILT FENCE SHALL BE SUPPORTED BY GALVANIZED STEEL WIRE FENCE FABRIC AS FOLLOWS:
   A. 4" X 4" MESH SIZE, W1.4 X W1.4 MINIMUM 14-GAUGE WIRE FENCE FABRIC
   B. HOG WIRE, 12-GAUGE WIRE, SMALL OPENINGS INSTALLED AT BOTTOM OF SILT FENCE
   C. STANDARD 2" X 2" CHAIN LINK FENCE FABRIC
   D. OTHER WELDED OR WOVEN STEEL FABRICS CONSISTING OF EQUAL OR SMALL SPACING AS THAT LISTED HEREIN AND APPROPRIATE GAUGE WIRE TO PROVIDE SUPPORT.
4. STONES IN STONE OVERFLOW SHALL BE HELD IN PLACE BY GABION BASKET.

SILT FENCE & STONE OVERFLOW STRUCTURE

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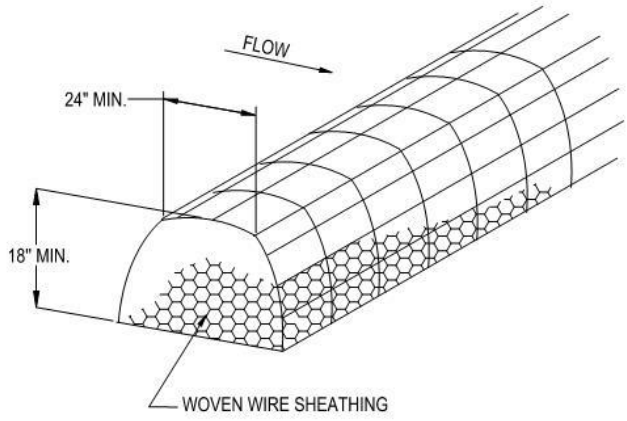
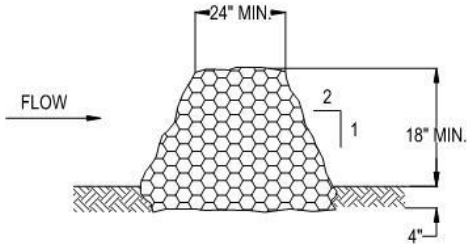


ROCK BERM

STANDARD SYMBOL
FOR ROCK BERM (RB)

RB



CROSS SECTION

NOTES:

1. USE ONLY OPEN GRADED ROCK 3" TO 5" DIAMETER FOR ALL CONDITIONS.
2. THE ROCK BERM SHALL BE SECURED WITH A WOVEN WIRE SHEATHING HAVING A MAXIMUM 1" OPENING AND MINIMUM WIRE DIAMETER OF 20 GAUGE.
3. THE ROCK BERM SHALL BE INSPECTED DAILY OR AFTER EACH RAIN, AND THE STONE AND/OR FABRIC CORE-WOVEN SHEATHING SHALL BE REPLACED WHEN THE STRUCTURE CEASES TO FUNCTION AS INTENDED, DUE TO SEDIMENT ACCUMULATION AMONG THE ROCKS, WASHOUT, CONSTRUCTION TRAFFIC DAMAGE, ETC.
4. IF SEDIMENT REACHES A DEPTH EQUAL TO ONE-THIRD THE HEIGHT OF THE BERM OR 6", WHICHEVER IS LESS, THE SEDIMENT SHALL BE REMOVED AND DISPOSED OF ON AN APPROVED SITE AND IN A MANNER THAT WILL NOT CREATE A SEDIMENTATION PROBLEM.
5. WHEN THE SITE IS COMPLETELY STABILIZED,THE BERM AND ACCUMULATED SEDIMENT SHALL BE REMOVED AND DISPOSED OF IN AN APPROVED MANNER.

TYPICAL ROCK BERM

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